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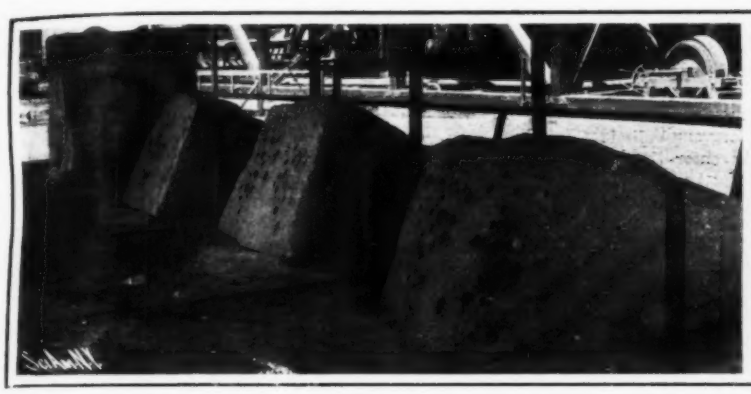
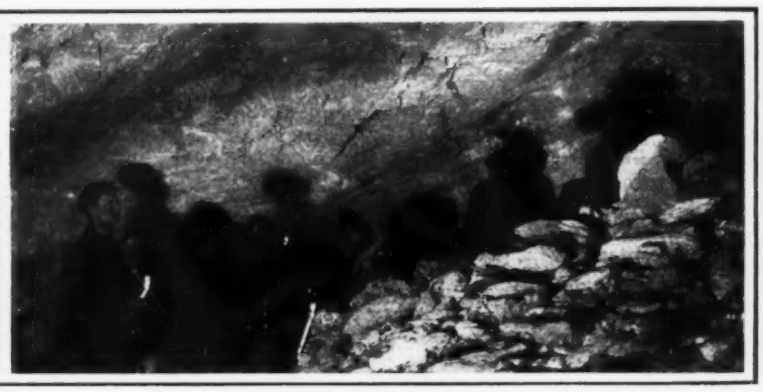
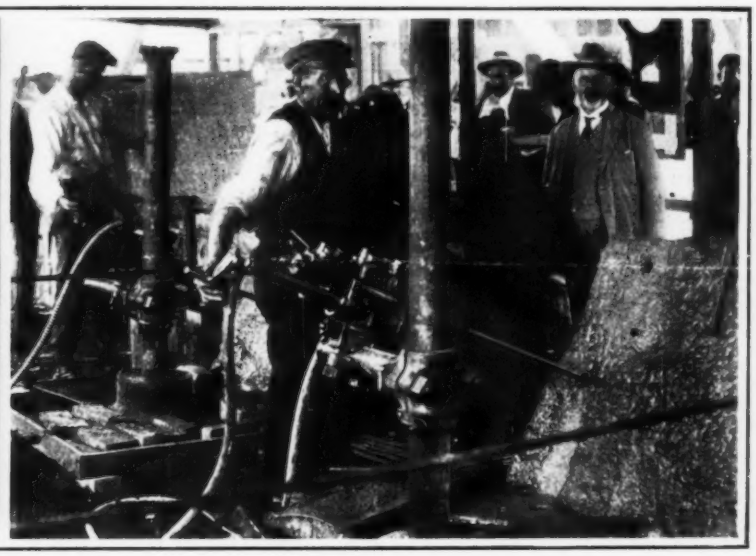


GRANITE BLOCKS USED IN THE TEST. "DRY" HOLES WERE DRILLED IN THE BLOCK AT THE EXTREME LEFT.

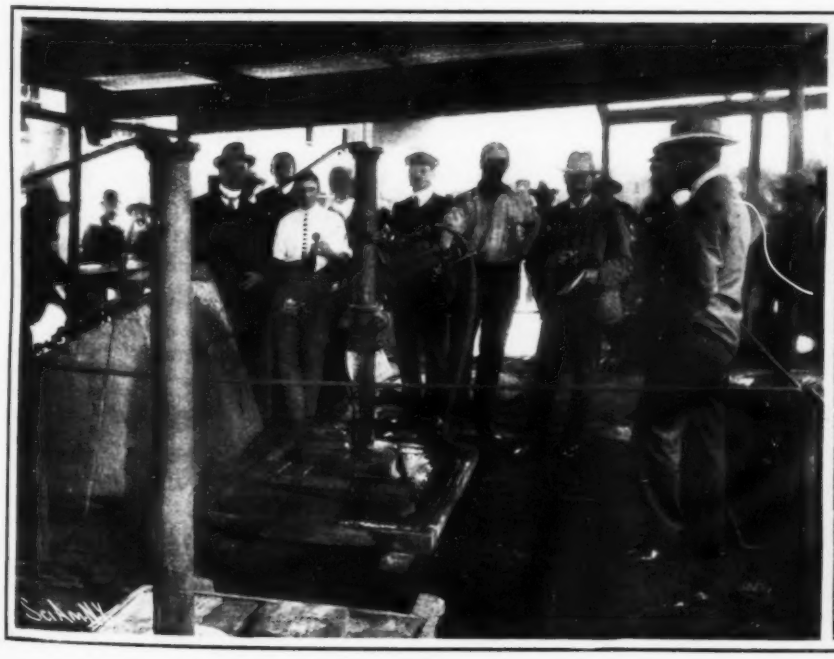


HAND STOPING BY CHINESE AT NEW KLEINFONTEIN. CHINESE HAVE BEEN DEPORTED. A MACHINE SUBSTITUTE MUST BE FOUND.

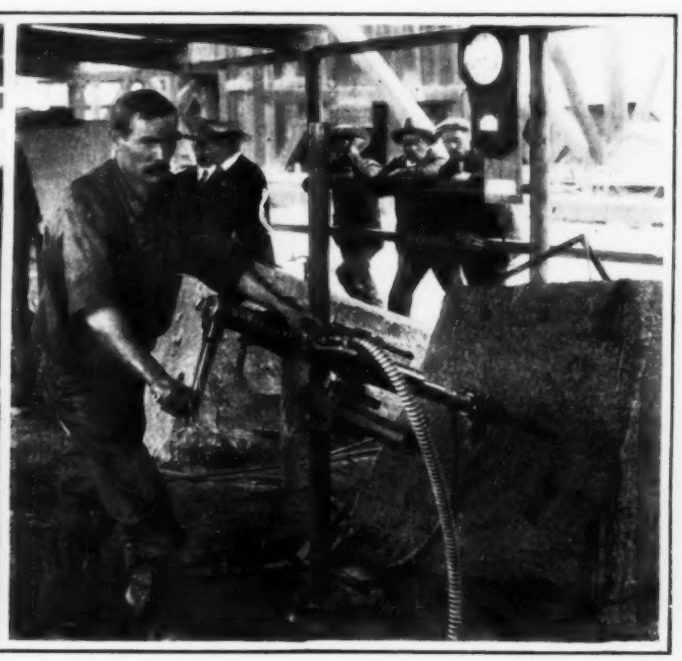
THE WINNER OF THE PRIZE AT WORK UNDERGROUND. THE MACHINE IS OF THE HOLLOW STEEL TYPE.



A MACHINE OF THE RECIPROCATING PISTON TYPE FITTED WITH DUST-ALLAYING SPRAY APPARATUS.



ONE OF THE SOLID STEEL PERCUSSIVE MACHINES.



SURFACE TRIAL OF THE SUCCESSFUL MACHINE.

A SECOND COMPETITION WILL TAKE PLACE NEXT YEAR FOR A FIRST PRIZE OF £4,000 ($20,000) AND A SECOND PRIZE OF £1,000 ($5,000).

A $25,000 STOPE DRILL PRIZE.

A $25,000 STOPE DRILL PRIZE.

A CHANCE FOR AMERICAN INVENTORS.

THE recent agitation in South Africa, resulting in the deportation of Chinese laborers, has confronted the mine owners with serious problems. Fifty-three thousand Chinamen were employed at the mines, drilling by hand a hundred thousand three-foot holes per day. Now a substitute must be found for the industrious Chinese. White help is too expensive, native help is worth little and cannot always be found, and the only relief seems to be in some improved mechanical drill.

In order to secure the very best drill for the purpose, the Transvaal government and the Transvaal Chamber of Mines have decided to hold a stope drill contest, open to competitors the world over. A prize of £4,000 is offered to the successful machine, and £1,000 to the second best stope drill. Aside from this reward, the successful competitors will undoubtedly have a market for several thousand drills in the various mines on the Rand. By a stope drill is meant a rock-drilling machine that will drive holes in small quarters, such as the narrow stopes or tunnels of a mine. In the final competition, the drills must work in stopes varying in width from 20 to 48 inches with a dip of from 20 deg. to 90 deg. Some of the principal conditions are as follows: The machines must be delivered in Johannesburg to the committee by the competitors' representative not later than the 31st of January, 1909. Each competitor must supply three machines, and each machine must not weigh over 100 pounds. In fact, it is desired that the machines be much lighter, so that they may readily be handled by a single man. With each machine a dust-allaying apparatus must be supplied, which may be either separate or a part of the machine. There will be two preliminary trials, one on the surface and the other underground, before the final underground competition under practical working conditions will take place. In the surface trial, the drilling will be done in granite blocks. All holes must be at least 42 inches and not more than 48 inches deep, and the last bit at the conclusion of the drilling gage at least 15/16 of an inch. Two machines of each entry will be tested for one hour of actual drilling time. The air consumption of each machine will be measured and taken into account when deciding whether a machine has passed the elimination trial. All entries which cannot drill the minimum of one inch per minute of actual drilling time will be eliminated. Machines that have passed the surface elimination trial may enter the underground elimination trial. Only one machine of each entry will be subjected to this trial. The trial will consist of three periods of eight hours each, including time spent in changing drills, rigging up, etc. Only three holes per rig-up will be permitted, and each rig-up must be at least fifteen feet from the previous one. In both the preliminary and final competitions, air pressure will be supplied at from 60 pounds to 70 pounds per square inch, as required by the competitor. At the conclusion of the underground elimination trial, all successful machines may enter the final competition, which will begin about April 1, 1909, and is expected to last six months. Two machines of each entry will be run for three hundred shifts each, day and night, continuously, with the exception of Sundays and legal holidays. Not more than two holes on any one rig-up will be counted. The competing machines will not be required to cut pillars, box holes, etc. The air consumption of each machine will be tested on the surface at least once a month during the competition, so that a good knowledge of the average consumption of the machine underground may be had.

The conditions of this competition are based on a previous test conducted under the auspices of the South African Mining Journal. There were twelve contestants in this competition, and on our front page will be found a number of illustrations showing the machines at work during the test. The winner of this contest was the "Gordon" machine, and the second prize was awarded to the "Chersen." From the very outset, the test resolved itself into a competition between the hammer type and reciprocating type of drills, and between hollow steel and solid steel, resulting decidedly in favor of the former. One of the conditions of this test was that each machine should drill "dry" holes in one of the blocks of granite. By "dry" holes was meant holes in which water could not be poured, but this did not prevent the introduction of water through hollow drills in machines designed to permit such lubrication. In the Gordon machine, which was of the hammer type, hollow drills were used, and water was introduced through the steels. The Chersen machine also used hollow steels. It was conclusively shown that with solid steels, no progress could be made in drilling "dry" holes. The test was conducted with air under a constant pressure of fifty pounds for the first four hours of drilling, and sixty pounds for the next four hours. Because of the enormous advantage of the increased pressure shown at this test the government decided to supply air at 60 pounds to 70 pounds pressure at the coming contest.

The work of the Gordon machine was remarkable for the small amount of air consumed, and for the lightness of the hammer used. The hammer of the Gordon weighed only about a pound, and the weight of the entire machine was 72¾ pounds. The Chersen, on the other hand, weighed 113¾ pounds, and consumed a much larger quantity of air. The actual footage drill by the Gordon was 28 feet 4⅝ inches at 50 pounds perssure, and 36 feet 9¼ inches at 60 pounds pressure. The inches drilled, per pound weight, in a four hours' drilling period, were 6.08 inches for the Gordon as against 3.50 inches for the Chersen at a pressure of 60 pounds per square inch. The amount of air consumed by the machines was not taken into consideration in the contest, as this point was not stipulated among the conditions. However, the importance of this factor was clearly brought out during the contest, and for this reason, in the coming government test, the amount of air consumed by each machine will be measured and considered in awarding the prizes. The coming contest will undoubtedly arouse great interest among mine owners and the manufacturers of drills, as it will undoubtedly afford an unbiased decision as to the best drill for the conditions at the Rand.

THE THEORY OF DIABOLO.*

A SCIENTIFIC EXPLANATION OF A TOY'S VAGARIES.

BY C. V. BOYS, F.R.S.

IT would be an interesting subject for a course of lectures or a series of articles to trace the effects of rotation in balls and other objects used in games and in other pursuits. Some of these are fairly obvious, as, for instance, the effect of a spin on a cricket-ball causing it to break after contact with the ground, or the effect of a screw in billiards, where the ball has a rotation about an inclined axis and bounces from the cushion at an angle which by no means obeys the laws of reflection. Here also, in consequence of the rotation the height of the cushion has to be seven-tenths of the diameter of the ball, for in the case of pure rolling the upper part of the ball may be considered to be traveling more quickly than the lower part, and so, if the cushion were only the height of the center the upper part of the ball would go on and take the rest of the ball with it. Less simple than these are the effects of the air in causing a spinning ball to veer away from the course that it would take if it did not spin. The best known of these is that shown by the flight of a golf-ball, which was first carefully investigated by the late Prof. Tait. When the ball is fairly struck by the club, the front face of which slopes somewhat backward, it is struck at a point below its center. The rotation imparted is in such a direction as to cause the lower part to move forward most quickly, and the front part to move upward. At one time it was supposed, and I believe clearly proved in the armchair in an analogous case, that the front portion moving upward would cause the ball to roll, as it were, upon the air compressed in front of it, and so cause a departure from the natural trajectory, which in the case of the golf-ball would be downward. As every one knows, the exact reverse is the case, and a proper consideration of the action shows that it should be so, for the air-pressure can be shown, both by theory and by experiment, to be greater below a ball spinning and moving in the directions followed by a golf-ball than above it. Prof. Tait established the fact that upward forces due to this cause may be set up which are two or three times as great as the weight of the ball. Another example of this, but less easily followed, is the flight of a spherical bullet from a bent smooth-bore barrel. If such a barrel is curved in a horizontal plane so as to be suitable, according to the story of our childhood, for shooting any one round a haystack, the bullet, far from continuing the curve which it was compelled to follow in the barrel, acquires therein a spin, owing to its rolling along on the concave side, and this spin produces a curvature when free opposite in kind to that of the barrel that gave the rotation. Such a curved flight of a ball is well known in games; the light ball of lawn tennis when well cut follows a markedly curved course, and, best of all, the child's India-rubber air-ball or balloon when cut by a sweeping stroke of the hand curves rapidly upward in its flight and provides the material for an excellent and violent indoor winter game.

Mysterious as some of these air effects may be, they are wholly eclipsed by the queer and apparently semi-contradictory effects of the rotation of a body which are noticed when anything is done to twist the axis of rotation into some other direction. If a grown-up and otherwise well-educated man had never seen a top spin, and, being familiar with the fact that such a body will not stand up upon its point when not spinning, and with the whole science of statics, were suddenly presented with the phenomenon of a spinning top, it is difficult to realize, familiar as we are with the result from our earliest childhood, how great would be his surprise. The fact that it should stand up at all would seem sufficiently uncanny, but its gentle gyrations round the upright position, more rapid as the rate of spin diminishes, would seem to defy explanation. It is only universal familiarity with the phenomenon that prevents surprise or any anxiety in the majority of people to dissolve the mystery. It would be out of place in an article such as this to prove from the simple laws of motion propounded by Newton that a top should spin as it does, or, more generally, how any spinning body will behave when any forces are applied to it which would, if it were not spinning, move the axis about which it happens to be turning into some different direction. This subject is treated in a charming manner by Prof. Perry in his book on "Spinning-Tops" and by Prof. Worthington in his "Dynamics of Rotation," and with rigid accuracy by Prof. Greenhill in his articles in the Encyclopædia Britannica. It is sufficient here to state shortly the facts. Take the case of the spinning-top. This, if not spinning, would fall over, the toppling-over effect of gravity being greater as the inclination is greater. When the top is spinning the forces due to gravity are the same as before, tending to drag the axis of spin over and downward, but in consequence of the spin it has a different effect: the axis does not move downward but sidewise, always at right angles to the direction in which it is urged, and so the top gyrates. Further, the rate of moving sidewise is greater as the rate of spin is less. If the point on which the top spins is adjustable so that it may be made to project more or less, or may be withdrawn until it is above the center of gravity, then as it is fixed nearer to the center of gravity the toppling effect of gravity will be less, and the top will gyrate more slowly. When the point on which it spins is at the center of gravity the toppling effect of gravity is destroyed, and so it ceases to gyrate, and when the point is raised higher still gravity tends to topple no more, but to set it upright: it then gyrates the other way. When gravity acts so as to make it fall it gyrates in the same direction as it spins; when gravity acts so as to set it upright it gyrates in the opposite direction. An example of a slow gyration of this sort is presented by the earth, which would, if it were

* Science Progress.

spherical, maintain the direction of its axis of rotation indefinitely. Any star in the line of this axis would be for all time the polar star. Both the sun and moon in their attraction upon the "equatorial protuberance," or excess of matter outside the sphere, act in such a manner as to drag it toward the plane of the ecliptic, or the earth's orbit round the sun. If this is looked upon as a level, then the sun and moon act together so as to set the top upright. The gyrations then are in the opposite direction to the spin, which is also the direction of revolution round the sun, and so the "equinoxes precess." The pole of the earth describes a circle round the pole of the ecliptic once in about twenty-six thousand years.

When a spinning body of other shape than a ball is projected through the air, the effects of the air upon the direction of the axis of spin, and hence on the motion of the body, give rise to numerous interesting problems. For instance, a disk spun and thrown by the right hand edgewise turns so that the right side of it rises and it veers to the left; on the other hand, a boomerang started with the same motion rises and comes back again. An elongated bullet neither follows the trajectory, like an arrow, nor maintains the direction of its axis, but conically screws itself around a line slightly above the trajectory. Whenever a spinning body is projected through the air which is in any respect different in its conditions from other cases which have been investigated, a new problem is almost certain to be found, and it is not safe to jump to conclusions.

In the case of the diabolo spool there are really no difficulties, because the air effects are barely noticeable, and they are of the simple kind observed with golf balls, tending to deflect the spool to the right as it falls if it is spinning rapidly with a right-hand spin. Ordinarily, in the drafty and eddying inclosures called gardens attached to houses in London, this deviation from a straight fall is not easy to detect, and it certainly is of no importance in the game. If, however, the spool were much lighter, and were ribbed or roughened like a golf ball, the air effect would be increased.

With an ordinary spool, the form of which it is unnecessary to define, the center of gravity is above the string support. It is therefore unstable, and on whichever side it happens to incline, on that side, if not spinning, it will fall. Gravity acts in such a manner as to topple the axis of spin over toward a vertical direction. With the usual right-hand spin the hands are moved in such manner that the string is jerked tight when the right hand is rising, and is loose when it is falling, and the spool gets its support mainly while the string under it is moving from left to right. The upper part, therefore, moves from right to left. In order to correct the level of the axis, when for any reason this ceases to be level, it is necessary to apply forces twisting it not in the desired direction, but in a direction at right angles thereto. Any child will tell you to put the left hand forward if the far end is drooping. Putting the left hand forward means the application of a twist on the axis, tending to turn the far end to the right. This may be proved in a moment by placing the spool on the ground with the string under it and then gradually lifting it with the left hand forward. It will then, not being in a condition of spin, immediately turn so that the far end moves to the right. If the left hand is put forward when the spool is spinning, the effect of the tendency to twist to the right is a movement in a direction at right angles to the tendency, and the far end rises. There are two directions at right angles to this tendency, one upward and one downward. It is puzzling sometimes to know which right angle will be followed. In the present case it is easy to tell by reference to the known movement of a top. Consider the axis of the spool to be the axis of the top and the far end to be the support of the top, or point on which it is spinning in an anti-clockwise direction, the direction of gravity being supposed for the moment away from you. The action of the string tending to turn the far end to the right or the near end to the left corresponds to the action of gravity on the top when it is leaning to the left, tending to make it fall more to the left. It does not do so, but moves sidewise in the direction of the spin, i. e., actually toward the earth; or, in other words, the other end, or far end, is raised. If the spin is left-handed of course the result is reversed, and so it is a pity when learning and acquiring the habit to base it upon a consideration which must be reversed when the direction of spin is reversed. The better instruction to follow is to jerk the business hand toward the high side—it being understood, of course, that the business hand is the one which, by its upward jerk, imparts the spin. With such a rule as the early guide the instinct, which is quicker than the recollection and application of any rule, is from the first directed aright, and no conscious effort of reversal is needed whether the direction of spin is right- or left-handed, or the near or the far end is falling.

In order not to be tied to the crab-like method of playing sidewise, which is so often seen, it is well to practise playing with a right or left spin indifferently. If playing alone, the change may be brought about by moving round to the side of the spool which is moving upward and catching the spool on the stick held by the passive hand, then in running the spool down on to the string it will be found to be reversed in direction as seen by the player, but not as regards the points of the compass. This catching on the passive stick is more easily effected, at first, at any rate, by catching on the active stick first and then catching it on the passive stick. The direction of spin may also be reversed by throwing the spool up and turning half round before catching it on the string. Quite a moderate amount of practice, reversing every time by one or other method, makes the direction of spin a matter of perfect indifference.

I have already referred to the fact that it is necessary for the player to make a half-turn if he would face the spool between every reversal. This is merely another way of saying that the spool maintains its direction in space—that is, it does so if it is perfectly balanced. It is impossible in that case, and provided that it is kept level, to get the spool to veer round to any appreciable extent. If the disturbances were a good deal less than they are, it would in this country appear to follow the sun, but at the reduced rate of nearly 12 deg. per hour, in consequence of the rotation of the earth. Though such accuracy is beyond practical attainment, the persistence of direction is very marked. If while spinning the diabolo a person walks round the garden, he will soon find he is getting his arms involved with one another, as the spool will not turn and the sticks must not either. Or if while traveling in the railway along a curve a passenger is spinning a diabolo and maintaining it level, the apparent turning of the spool will indicate the actual turning of the carriage in the opposite direction.

I have insisted upon the necessity of keeping the spool level when making this experiment. Suppose, for instance, that the far end is down a little and that the usual right-hand spin is being applied, then, as the far end is down to a certain extent, the center of gravity, instead of being above the string, is on the far side of this position, and gravity tends to topple the spool over on the far side—i. e., to turn the spinning axis so that the far end moves downward. Just as the tendency of the string support to turn the far end to the right makes it actually rise, as already explained, so this tendency of gravity to make the far end move downward causes it, in consequence of its rotation, to go sidewise, and the particular sidewise tendency in this case is to the right. If, then, a player desires to work the spool round he has merely, by thrusting one hand forward, to make one end dip somewhat, and then to keep spinning it in that position, when it will veer round—more quickly if the spin is slow—and then, when it has the required direction, to bring the low end up again by drawing the same hand toward himself. It does not matter whether the spin is right- or left-handed; if the right hand is put forward to cause one end to dip, the spool will then veer to the right, and *vice versa*, for the end that dips is reversed with a reversed direction of spin, and the action of the reversed tendency to fall, combined with the reversal of spin, gives the same direction of veering. This process was described by a speaker at the Physical Society at a recent meeting where I was showing a peculiar spool, to which I shall next refer.

An ordinary fly-wheel or a disk is twice as effective as a fly-wheel if it is mounted to spin in its own plane as it would be if it were made to spin on one diameter as an axis. Its moment of inertia is said to be twice as great when spinning as it does in practice as it would be if made to spin about a transverse axis. On the other hand, a diabolo spool or an elongated bullet is less effective as a fly-wheel when spinning about its axis of rotational symmetry. In these cases the moment of inertia is a minimum, while in the former it was a maximum when spinning in the usual manner. Anything, whatever shape it may have, must have some direction about which the moment of inertia is a maximum or a minimum, and it may have a single transverse axis about which it is correspondingly a minimum or a maximum.

If any body is set spinning about any axis and then liberated, it will continue to spin about that axis and resist disturbance only if the axis of spin is one of maximum or minimum moment of inertia. If the body were spun about any inclined axis and liberated, then, according to the position in the body of the inclined axis and the relative values of the maximum and minimum moments of inertia, the axis about which it thereafter is momentarily spinning will move within the body according to one curve and in space according to another, for which an explanation must be sought in Maxwell's Collected Works, vol. i., page 248. If, on the other hand, the spinning body were a uniform sphere, in which the moments of inertia about all diametrical axes are alike, it would have no tendency to move the axis of spin in any particular manner within itself, and any disturbance would set this axis wandering in the sphere, or, as Maxwell put it, the sphere has no dynamical backbone.

It is not necessary in order that a thing should have equal moments of inertia in all directions that it should be spherical in shape. A long round thing has a minimum moment of inertia about its axis of symmetry, while a flat round thing has a maximum moment of inertia about this axis. A bullet or an ordinary diabolo spool is an instance of the former, while a fly-wheel or a disk is an instance of the latter. A diabolo spool need not have the usual angle of about 70 deg., it may be made longer or wider. As it is made wider the moments of inertia in the two directions become gradually more alike, and if it were made wide enough it would correspond in this sense to a fly-wheel, and the respective values would be inverted. There must be, therefore, some intermediate width or angle of cone which makes the moments of inertia in all directions the same, so that dynamically it is the same as a sphere.

It is easy to prove that in the case of a thin, hollow double cone, with the ends open and joined point to point, the proportion which gives the spherical characteristic is reached when the angle of the cone is nearly 110 deg., or when the tangent of the semi-vertical angle is $\sqrt{2}$. All matter added to such an ideal skeleton without it equatorially makes the axis of rotational symmetry an axis of maximum moment of inertia, all added beyond in the direction of the axis makes this a minimum. A judicious addition of matter without and beyond leaves the double cone dynamically the same as a sphere. If, then, a spool is made of this angle, and of such a thickness as to give a convenient neck for the string by addition of matter without the ideal cone, and by the addition of about the same amount beyond the ideal cone, the resulting spool will be dynamically very nearly a sphere. It is best to make it with an axial hole and with a very slight preponderance of matter without the ideal cone. The moment of inertia about the axis of spin is then just a maximum and the spool spins perfectly. A number of sticks may then be made of different lengths and thrust centrally, one at a time, into the hole. If any one of these is so exactly chosen in length as to make the moments of inertia in all directions the same, then spinning becomes impossible for the reasons given. In order to ascertain if any stick is too long or too short it is merely necessary to suspend the combination from a torsion wire so as to oscillate about the axis of rotational symmetry and about a transverse axis successively. Then if the time of oscillation about the former is the greater, the stick is too short, and *vice versa*. In order to make spinning really hopeless the time of oscillation should not differ by anything like so much as 1 per cent, but when equality to this extent is reached the spool becomes sufficiently unmanageable.

When a stick has been properly adjusted the equality fails if the stick is not centrally placed, and the spool can be spun again quite easily. Now, however, being out of balance, the heavy end in tending to fall actually goes sidewise, and more quickly so at starting, when the spinning is slow. With a right-hand spin the heavy end, whichever way it is pointing, veers to the right. This may, of course, be equally well shown with any spool which is unbalanced, or which is made so by attaching a nail or a lump of wax to one end. A stick too short to give the spherical property when centrally placed may, nevertheless, do this when pushed out of center, and then, though the combination will spin perfectly in the first position, it is impossible in the second.

It might be thought that the ball in the game cup-and-ball, which at least is a sphere in fact, should not maintain its axis when spun with a view of being caught on the point. But here there are two answers. The first is that though outwardly a sphere the axial hole made for the point to enter destroys its spherical properties. This may be the case to the extent of an inequality in the moments of inertia of perhaps as much as 5 per cent, and this is quite enough to give stability. I have, however, turned a groove in the equator of a well-made ball of this kind to such an extent as to bring the moments of inertia the same, at least to a small fraction of 1 per cent. I was rather surprised to find that I caught this sophisticated ball the first time I tried it. The case, however, is not parallel with the diabolo spool in this respect. While the tweaking of the string on the spool is certain not to be exactly symmetrical and free from disturbing influences, the axial string from which the ball is suspended lifts it when spinning with a pull which must be as truly axial as the turned work is round, and so the disturbance, if any, must be so slight that the ball, in the short time that it is free, has no time to take up an appreciably different position before it is caught. All the time that it is on the string it is held true, while, on the other hand, the spool is only supported and tweaked by the string a very small fraction of the whole time.

Of all the appliances in the class room for illustrat-

ing the precessional properties of rotating bodies I do not know one which is so inexpensive, simple, and handy as the now popular diabolo. It is whispered that mathematical professors do not always illustrate what they wish very successfully when using gyrostats and Maxwell and other tops. The diabolo seems to have been invented for their special benefit. A complete and proper demonstration of the points described above, and of many others, no doubt, would add enormously to the joy of the class. If at any time the spool should prove refractory the expositor could fall back upon the convenient formula $\tan\theta = \sqrt{2}$, which in time might be contracted to tan, and would so serve the double purpose of an explanation and a harmless but comforting expletive. As a game I do not at all feel inclined to agree with the view that it is not worth while, that it is silly, that it is a mere passing craze. It may, and no doubt will, go out of fashion as quickly as it came in, if indeed it has not already done so, but that is not the fault of the game but of society.

ELEMENTS OF ELECTRICAL ENGINEERING.—XXI.

PROTECTIVE APPARATUS.

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY.

Continued from Supplement No. 1695, page 406.

ELECTRIC circuits are peculiarly subject to disturbance from accidents. Naturally associated with delicate and sensitive apparatus, interference from almost any untoward source is at once felt, often in violent degree, alike dangerous to person and apparatus.

Interference with the normal working may come from within the dynamo machinery itself, due to the breaking down of the insulation, from accidental or mischievous tampering with the exterior circuits, or from the action of elements. From the first cause, if the accident is in the original source of the currents, there is little remedy. If an armature is overloaded to an excessive amount, there is no reason why the abnormal heat should not burn out the insulation and destroy the winding. Once the trouble is away from the machine, various protective devices can be inserted that will localize or minimize its disastrous effects.

The necessity for some such devices was apparent from the very first installations of electric lamps on the constant potential, or "Edison" system. In this, every lamp was directly connected across the two

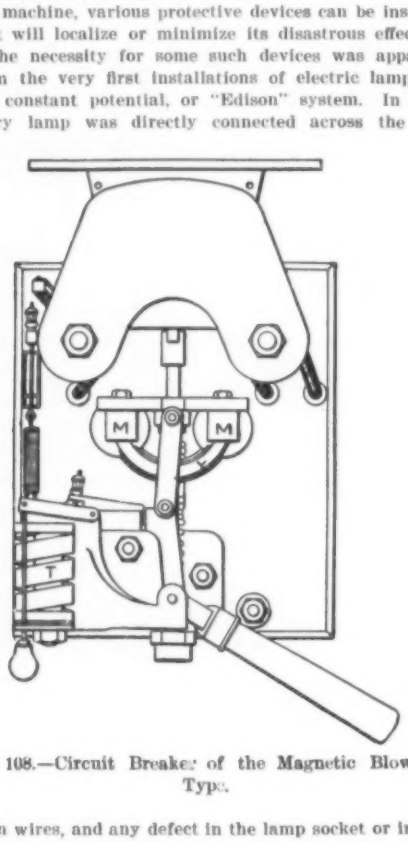


Fig. 108.—Circuit Breaker of the Magnetic Blow-out Type.

main wires, and any defect in the lamp socket or in the wiring, or from malicious or curious meddling with the wires, meant a direct short-circuit through which the entire dynamo power might try to send an unlimited current. Aside from the flash and consequent danger of burning the person, the wires leading to the fault might be quickly heated to such a degree as to constitute a real fire risk, and if the trouble was between sufficiently large conductors, to derange the entire system, and also endanger the dynamos and switchboard apparatus. Relief from such troubles, increasing naturally with the size of the installation, was found in the insertion of "fuses" at proper intervals, wires or strips of readily fusible metal, composed of a mixture of lead and tin about the same as fine solder; the current for every branched circuit was made to pass through a suitable piece of this alloy, and in case of an abnormal demand, the fuse would melt, and prevent the trouble from spreading further. A regular rule is now insisted upon to put fuses wherever the size of wire changes, thereby protecting the smaller wire. As the distributing mains reach further and further from the station, the amount of current for any locality diminishes, and it is economy to reduce the size of the conductors. By apportioning the fuses to fit the current carrying capacities of the different sizes of wire, as determined by the result of years of practical experience, derangement and danger are reduced to a minimum. Also in the house wiring, main fuses are found in the entrance cabinet, so that an accidental short-circuit there will merely "blow" them, but not interfere with the neighbors' service. Smaller fuses are placed in each individual circuit to

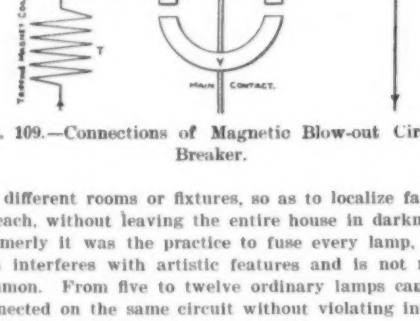


Fig. 109.—Connections of Magnetic Blow-out Circuit Breaker.

the different rooms or fixtures, so as to localize faults in each, without leaving the entire house in darkness. Formerly it was the practice to fuse every lamp, but this interferes with artistic features and is not now common. From five to twelve ordinary lamps can be connected on the same circuit without violating insurance rules or good engineering practice.

The house cabinets make convenient and appropriate locations for these final fuses, and when comprised in the familiar Edison "screw-plugs," make a combination destined to be well-nigh final. As compared with the earlier preposterous plan of putting the fuses on the ceiling, in boxes far from fireproof, often requiring the use of a screw-driver, and frequently in the dark, at the top of a rickety step-ladder, the present orderly method can be the better appreciated. This allowance for convenient and safe "fusing," was one of the most perfect details of the Edison system. To provide against danger of destructive arcs forming after the melting of a fuse on 220 and 250-volt circuits, the fuses are now commonly inclosed in paper tubes filled with plaster, but the original form, merely covered with a brass cap, is entirely sufficient for low-voltage circuits.

In their original development of the underground system of conductors, the Edison Company devised very effective and complete varieties of junction and service boxes. These were made of cast iron, their covers level with the pavement, and strong enough to withstand the heaviest vehicular traffic. Below the upper cover was a water-tight one, and in the inclosed space were the various fuses tying together conductors of the same polarity. From these junctions the indi-

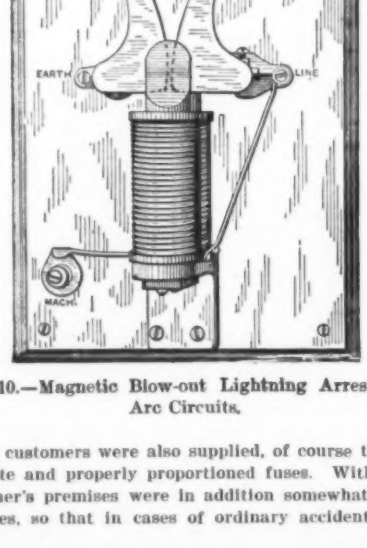


Fig. 110.—Magnetic Blow-out Lightning Arrester for Arc Circuits.

vidual customers were also supplied, of course through separate and properly proportioned fuses. Within the customer's premises were in addition somewhat smaller fuses, so that in cases of ordinary accident, these accessible ones would be melted, reserving the function of the outdoor ones to care for more unusual conditions, especially the failure of the insulation of the service wires in the street.

A fuse, however, is a safety device that, like the fusible plug in the bottom of a steam boiler, is there for emergency, but not expected to be of frequent necessity. It is merely a sort of insurance against serious accident. There are circuits of another sort that may be in need of control from excessive currents, and the demands for momentary large current so frequent as to make the repeated renewal of fuses inconvenient, slow, and even dangerous. Such are power circuits, especially of the railway sort. If an injudicious motorman tries to start a car too quickly, or to go up a grade at too high a rate, the demand for current may exceed the safe capacity of the motors, and the necessity for a fuse or its equivalent is always needed. Then, too, there may be some breakdown of the motor or the controlling devices, and precautions against accidents of this sort must be provided. To prevent the formation of the destructive arcs that would readily follow the rupture of such energetic currents, the fuse boxes are made of the "magnetic blow-out" type. In this the fuse lies be-

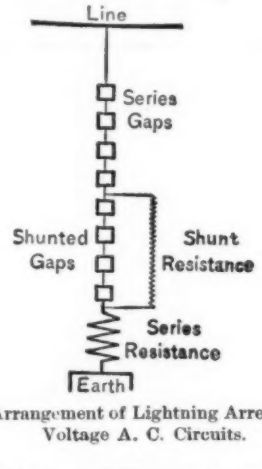


Fig. 111.—Arrangement of Lightning Arresters for High Voltage A. C. Circuits.

tween the poles of an electro-magnet, energized by the current sought to be broken, and in consequence of the action of the magnetic field, the arcs are forcibly swept away.

The principle of the magnetic blowout is merely the motor rule as illustrated by the fingers of the left hand, and explained in Chapter VII. The experiment is strikingly carried out by means of a strong permanent magnet held flatwise close to the arc of an electric lamp. With the current flowing down through the carbons, and the north pole of the magnet on the right, the arc will be strongly deflected away from the person. Turning the magnet over will allow the arc to come nearer. Too close a holding of the magnet will completely extinguish the arc, though by the automatic action of the feeding mechanism the arc will form immediately after each extinction. Prof. Thomson patented the application of the magnetic blow-out to uses in apparatus for effectually and safely breaking powerful currents, and thereby for a time monopolized one of the most useful principles of controlling electric circuits. The applications of this principle were not limited to ordinary working circuits but extended to a highly serviceable form of "lightning arresters."

One of the most trying conditions for a railway power house occurs immediately after a street blockade, of frequent occurrence in cities, for then the whole line of cars may try to start at the same instant. The demand for current may exceed the safe capacity of the generators or of the particular feeders. The supply must momentarily be withdrawn, but to break a current of say a thousand amperes under a driving force of 500 volts, without injury to the switch

or other device, is no simple matter. When the coming off of the wire of an ordinary trolley, breaking a current of 50 amperes, is attended with a flash a foot long, what will the larger current do? Without suitable precautions to prevent the flash or arc, the destruction of an entire switchboard would be invited.

Prof. Thomson's circuit-breaker, as made for currents as high as 3,000 or even 5,000 amperes, is shown in front view in Fig. 108, and a diagram of the connections in Fig. 109. In the lower left-hand corner is seen the tripping coil *T*, through which all the current passes. It is made from a copper spiral of few turns, and no small ingenuity has been displayed by the builders in devising means for winding it of the large size of copper needed. Over the iron core within this spiral is an armature, pivoted as seen, and restrained by an adjustable spiral spring just over it. Extending from this armature to the right of the pivot is a trigger, and when the "breaker" is set, the toggle joint in the middle of the figure is so engaged as to be prevented from opening. A stiff spiral spring, just discernible behind the toggle, has its lower end fastened to the bottom casting, but its upper to a vertically sliding rod that carries at its middle a semicircular bridge *Y* composed of a large number of thin copper sheets, and at its upper end a solid copper wedge that fits between a pair of "blow-out" contacts. The lamellar copper bridge is normally pressed into firm contact with the two flat contacts *M*, its separate edges providing a joint of almost no resistance. At the top of the figure is seen a curved casting, but in reality there are two such, each about half an inch thick, connected together with two iron cores about three inches long, around which are the coils for producing the magnetic field. These coils are of wire about a quarter of an inch in diameter, but do not carry appreciable current for more than an instant.

In operation the current normally flows through the coil *T* to the left-hand contact *M*, through the bridge *Y* to the other contact *M*, and then to the outer circuit. With so good a path at the bridge there is little current flowing in the magnet coils at the top. If now an abnormal current flows, the armature over *T* is pulled down, thereby releasing the toggle, which, under the pull of the spring, is jerked open toward the left, and the connection between *M* and *Y* is broken. If this were all, however, the current would still flow across the relatively small gap, to the destruction of the instrument and the failure to protect the apparatus in the desired manner. Although *Y* has separated from *M* there still remains for an instant an alternative path through the magnet coils at the top. The abnormally large current magnetizes the pole pieces to a high degree, and when the final break does take place, at the separation of the wedge from the blow-out contacts, the arc finds itself in a powerful magnetic field, and is blown violently upward through the fiber-lined chimney. With large circuit breakers the rupture of the arcs is accompanied with a crack like that of a pistol fire. The circuit is quickly and safely closed again by an attendant pulling down the handle. In case it is desired to open the circuit purposely, and not endanger the main switch on the switchboard, or to produce a blinding flash, the circuit breaker is the device to use, by pulling down the armature by means of the knob shown at the lower left-hand corner.

So successful have been these circuit-breakers that they have been copied in various sizes and styles and used on various other sort of circuits. On the railway cars themselves, especially the large ones, they have very properly displaced the simple fuse. Aside from the convenience of again closing the circuit, after the fault has presumably been removed, there is the extra advantage of greater exactness in the point at which the circuit will be opened. An ordinary fuse is quite erratic or indeterminate in this respect. The length of the fuse, the form and mass of the blocks to which it is attached and the opportunity for radiating its heat all interfere with an exact prediction as to the particular strength of the current that will produce fusion. The present approved forms of inclosed fuses are largely free from these interfering influences, but their cost renders their use prohibitive for places liable to frequent service.

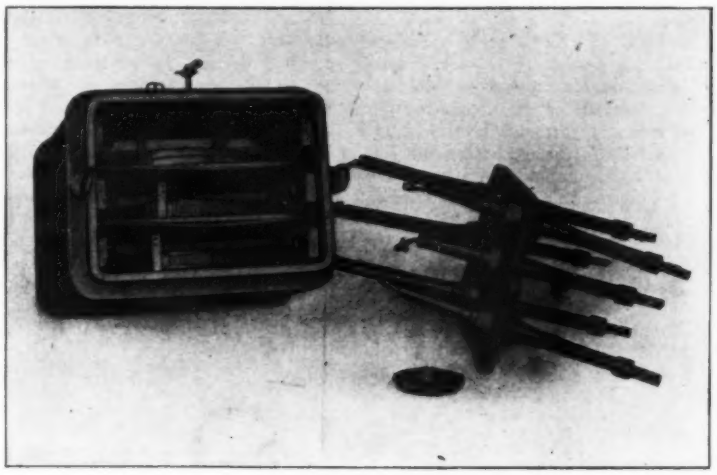


Fig. 112.—Choke Coils.

The magnetic type of circuit-breaker is not the only possible form, for other constructions, more nearly resembling ordinary switches, are somewhat cheaper, and have demonstrated their worth. In these the current normally flows through the copper contacts, but when tripped by the action of the electro-magnet or solenoid, this contact is broken, but the final break takes place from carbon blocks at the top. Though somewhat burned by continued use, these blocks are of inconsequent expense and are readily renewed.

For storage battery use, a circuit breaker is needed that will open under reversed conditions, i. e., when the charging current from the generator gets below a certain minimum. This is needed to protect the batteries from needless discharge, and especially in case a compound-wound generator is employed, for then an accidental discharge of the battery would mean a reversal of polarity of machine, with opportunities for serious accident. For such a contingency, it would be hoped that the over load circuit breaker would be able to open the circuit, and protect the apparatus from actual injury, but in some cases the violence of the discharge of the battery, with the dynamo in series conspiring to magnify the disorder, is such as to destroy the protective apparatus itself, and burn out the armature.

One of the first troubles experienced with aerial electric lighting circuits was from lightning. When the wires were struck, the discharge would reach the windings of the dynamo, then rather than pass through the coils, would jump to the iron cores, and then the dynamo current itself would follow the path of the rupture and complete the destruction of the insulation. To devise means for protecting the dynamos from such untoward influences would seem almost impossible. Yet the means have actually been found, remarkable in simplicity and efficacy. The principle of the magnetic blow-out was really first invoked to provide the immunity desired. Following earlier phraseology adopted in telegraph matters, the devices were curiously denoted as lightning "arresters." This is really a misnomer, for of all things a person would not try to "arrest" lightning. The opposite is the real intention, that is, to let it go, and that by the most direct route to the ground. Perhaps lightning "deflectors" would have been a more correct expression.

The simple form of arrester devised by Prof. Thomson for use on series arc lighting circuits is shown in Fig. 110. A vertical electro-magnet is attached to a board for fastening on the wall or switchboard; a space of about an inch and a half intervenes between the poles, and in the middle of this space two brass "horns" are fixed, with their nearest edges about a thirty-second of an inch apart. Of these the right-hand one is attached to one end of the winding, while the other horn is "grounded." The other end of winding is brought out to a third terminal. In actual use one of these devices is inserted in each of the line wires, the winding being of a sufficient size to carry the entire current, which however never exceeds ten amperes. The iron is therefore always magnetized, and if any lightning discharges come in on either wire, the inductance of these coils is such as to encourage the jumping of the spark or flash over the small gap, and to pass at once to the ground. In times of storm considerable leakage of current from the regular line insulators or from contact with trees is expected, so that as soon as another ground is provided by the lightning jumping the narrow crevasse, the dynamo current will follow it and maintain a destructive current after the original cause had passed by. Especially would this be the case if the jumping at the gaps in both arresters took place simultaneously, for then the double ground would leave the dynamo operating directly upon a short-circuit. The magnetic field embracing the horns, together with the natural tendency of heated air to rise, urges the arc to higher portions of the horns, until at length the distance is too great, and the arc breaks. Actually the whole performance is rather rapid, the arc or flame quickly passing up and off like a momentary flame.

Similar constructions of arresters are commonly placed on street cars, directly in the circuit between

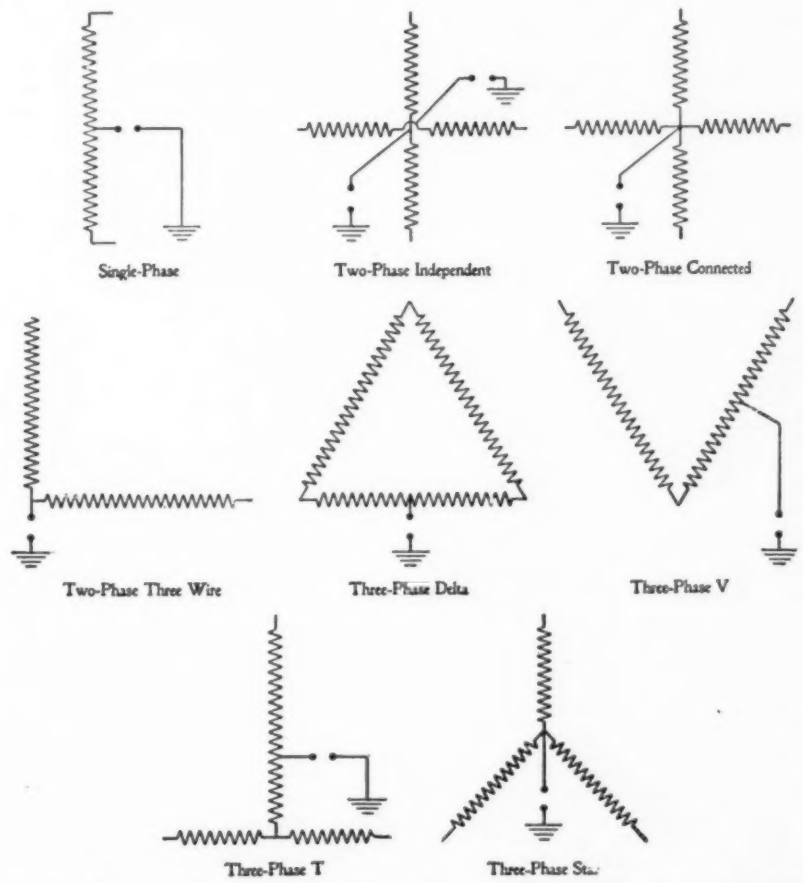


Fig. 113.—Location of Spark-Gap or Ground Connections for Various Arrangements of Transformer Secondary Circuits.

the trolley and the controller. It is worth noting, however, how simple an expedient made their operation quite reliable as compared with previous erratic performance. Violent discharges of lightning are usually of the oscillatory character, that is instead of one single passage of the current, there are many, in successively opposite directions, with a frequency approaching millions per second. These discharges therefore behave like alternating currents of extremely high frequency, and a coil of even a few turns of wire may offer serious impedance to their passage. To compel the lightning to jump the small gap rather than enter the motor and there puncture the insulation, four or five turns of wire wound on a wooden core for stability, entirely suffice to secure the desired protection. To an ordinary observer these "choke" coils appear useless and meaningless, but to the expert engineer or scientist they speak silently of a notable triumph of man over some of the most mysterious and dreaded forces of nature.

Alternating current circuits present special problems in the matter of protection from lightning. Due to the great area embraced, especially in long distance transmissions, where the storms are protracted and severe, such circuits are particularly subject to collecting heavy static charges or to be struck by direct bolts. The magnetic type of arrester has been found unsuitable for alternating currents, and recourse to other constructions has been compulsory.

Without trying to describe all the various styles that have been tried, it will be sufficient to mention one sort, that with various modifications to fit the demands of higher and higher voltages of generators embodies the most successful features.

Almost by accident, Mr. Wurts, of the Westinghouse Company, found that alternating currents would not sustain arcs between balls or cylinders of cadmium, or certain cadmium alloys. Lightning could jump across the narrow gaps, but the dynamo current could not follow. Of course the actual number of such gaps to interpose in a given circuit was a matter to be found out by experiment. For circuits not exceeding 1,500 volts, seven cylinders were found sufficient, and these were arranged in a row in porcelain holders placed in an iron box and mounted on the poles. The end cylinders were attached directly to the two line wires, and the middle one to the ground.

For high potentials, 10,000 volts or more, further gaps and resistances of other sorts have been tried with success, each of the factors serving to contribute its qualities to the proper working of the entire apparatus. These comprise (a), series gaps, a number of the sort of gaps just described; (b) other gaps shunted through resistances or by-paths; and (c) series resistances. A diagram of the arrangement is given in Fig. 111. One such arrester is attached to each line wire at each end of a given transmission line. When sufficient accumulation of electricity has taken place on a wire, or if the line has been "struck," the discharge takes over the series gaps, and for ordinary disturbances may flow then through the shunt resistances and then the low series resistance to the ground. A heavier discharge will meet such opposition in the shunt resistance as to be compelled also to jump the shunted gaps. The arc formed by the dynamo current following the lightning flash will be quickly eliminated by the continuous path afforded by the shunt resistance, and then this resistance together with that of the series portion and of the series gaps will completely suppress the entire flow to the ground.

To make the operation still surer, and protect the generators from even minor discharges, choke coils are inserted in each of the mains, between arresters and switchboard apparatus. Such coils need to be extremely well insulated, and though often suspended on brackets in some open place behind the switchboard, are better submerged in tanks filled with paraffin oil. Fig. 112 shows a triple-pole device of this sort, adapted for high potential three-phase circuits. The long leads are covered with hard rubber, the design being to remove the opportunity of side-flashes. The arresters are usually placed on the outer walls of buildings, but considerable favor is found in placing this part of the auxiliary apparatus in separate and small structures adjoining the main power houses. Destruction by lightning of such buildings is of small consequence compared with that of the loss of the main works.

For the various methods of grouping the circuits of alternating current generators, particular methods of attaching the arresters should be followed, with the idea to allow disturbances from lightning to produce the least derangement of the system and freedom from personal danger. When transformers, too, are to be protected, the possibilities of variations are quite numerous, and a representation of eight standard groupings with proper locations of grounds is clearly given in Fig. 113. These windings are on the low-tension side, as the primaries are supposedly protected by their own arresters. For these low-voltage windings a single spark gap is sufficient, and in case the voltage is not over 250, actual permanent grounding of these points is not only permitted but encouraged by insurance regulations. While such grounding invites danger of breakdown of the insulation between primary and secondary windings by providing a nearly metallic path from line to ground, it also forbids the existence of any other ground anywhere in the wiring. Should such be encountered, the fuses would immediately blow and require repairs before again establishing the service.

With grounds thus purposely provided, there is not the need that was formerly felt for "ground-detectors." Some can still be found, however, in isolated plants. The simplest form consists in putting two lamps in series across the main bus-bars of the switchboard. The wire that connects these two lamps is connected to the ground. Every day, or as often as desired, the current is turned on, but normally the lamps burn very dim. If a ground is actually encountered in the wiring, it short-circuits one of the lamps, thereby allowing full voltage to be impressed upon the other, at once raising it to normal incandescence. The ground is then to be looked for on the wire to which the extinguished lamp was connected.

RECIPROCATING ENGINES AND TURBINES.*

A COMBINATION OF THE TWO.

BY C. A. PARSONS, D.SC., M.A., AND R. J. WALKER.

IT may be said that perhaps the most important field for the combined system of machinery, as applied to marine propulsion, is for those installations where the designed full speed of the vessel falls below the range suitable for an all-turbine arrangement, the reciprocating engine working in the region of pressure drop where the conditions are best suited for it, and the turbine utilizing that portion of the expansion diagram which the reciprocating engine is not able to utilize efficiently. It is generally well known that an all-turbine arrangement has not been advocated by us for ships where the designed speed falls below 15 or 16 knots, excepting in some special cases, such as yachts; and for vessels of moderate or slow speed the combination system of machinery appears to be eminently suitable.

In a good quadruple reciprocating engine, the steam is expanded down to the pressure of release, about 10 pounds absolute, and gains in economy as the vacuum is increased up to about 25 inches or 26 inches, whereas in a turbine it is possible to deal economically with very low-pressure steam, and to expand this low-pressure steam to a low absolute pressure corresponding to the highest vacuum obtainable in turbine practice.

In a combination system, the most suitable initial pressure for the turbine, or the dividing line between the reciprocating engine and the turbine, will greatly depend upon the conditions of service of the particular vessel taken. The reciprocating engine, or engines, can be designed to exhaust at a pressure of between 8 pounds and 16 pounds absolute, or even at a slightly higher pressure, if necessary, to meet the conditions required. From an estimate of the theoretical efficiency under the various conditions of pressure, it would appear, apart from any practical considerations, t there is nothing to choose between an initial pressure at the turbine of between 7 pounds and 15 pounds absolute, any pressure within this limit appearing to give the most economical result.

In the case of a vessel which runs on service continually at or about her designed full speed, an initial pressure of about 7 pounds absolute at the turbine appears most suitable. In a vessel which does part of her running at the designed power, and part at a considerably reduced power, it is desirable to design the turbines so that the initial pressure would not fall below 7 pounds absolute when running under the lower conditions of power. With a quadruple-expansion reciprocating engine exhausting to the condenser direct, the maximum energy realizable from 200 pounds pressure to 26 inches vacuum, with point of release at 10 pounds = 256 B. T. U. The energy which the reciprocating engine cannot efficiently utilize, but which can be used in a turbine = 73 B. T. U.

In a combination of triple expansion engine exhausting to a turbine and thence to the condenser, the maximum energy realizable from 200 pounds to 8 pounds, with point of release at 13 pounds = 219 B. T. U. The energy available for the turbine from 7 pounds to 28 inches vacuum, receiving wet steam from the reciprocating engine = 100 B. T. U. Total energy of combination = 319 B. T. U., which is 24½ per cent greater than that of the reciprocating engine. (All pressures are absolute.)

It is estimated that a large portion of this additional energy can be expected to be realized by the combined system in the shape of increased power to drive the vessel, or, on the other hand, increased economy. These figures (theoretical) are computed on the basis of adiabatic expansion throughout.

Thus, it is estimated that a quadruple expansion engine using 95,000 pounds of steam per hour at 200 pounds pressure will develop 7,300 I. H. P., working on a 26-inch vacuum. The same quantity of steam (using a 28-inch vacuum) will operate a 6,300-horse-power triple-expansion engine and a 2,000-horse-power low-pressure turbine, or 8,300 I. H. P. in all, an increase of 13.7 per cent. A speed of 15.5 knots would be obtained with the former and one of 16.2 knots with the combined installation. The total steaming weight would be about 3 per cent less with the combined installation.

* From a paper read before the Institution of Naval Architects.

CLARIFYING WASTE WATER FROM DYE WORKS.

By ROBERT GRIMSHAW.

ONE of the largest Austrian textile manufacturers desired to find some method of clarifying the waste water from his dye works, so that it could either be discharged into the Wildbach River without doing injury to the fish or be used for boiler feed, etc.

This water was charged with wood dyes, various aniline and alizarin pigments, fats, and mechanical impurities; was of a deep green color, and smelled like ink.

Shaken up with fusel oil, the upper oil layer was colored emerald green, the lower ones remaining dirty green. Dilute sulphuric acid colored it a still stronger sap green; alkaline lye, light brownish green. Both these reagents were therefore without any bleaching or clarifying action.

Gawalowsky, to whom the matter was confided, tried a number of materials for removing the color, with the following results:

1. Soda made a green precipitate; the water, however, remained, although clear, intense green.

2. Lime gave a clay-yellow precipitate, with brownish liquid.

3. Soda and lime had the same effect as lime alone.

4. Barium superoxid, with and without the addition of sulphuric acid, had no more effect than the first three.

5. Ammonia salts and lime gave a brackish brown precipitate, with brown liquid.

6. Superphosphate, alum, and lime gave a green precipitate, with green liquid.

7. Permanganate and sulphuric acid, with or without the addition of superphosphate and lime, gave at first a brown, then a whitish muddy precipitate; the liquid above being clear but intensely straw yellow.

8. Iron chloride and lime gave a deep brown precipitate, but the liquid above was deep straw yellow.

9. Potassic alum and lime produced a green precipitate; the liquid being quite clear and quite well deprived of co r, but with a greenish tinge.

10. First a solution of lime, then lime chloride, and afterward lime, gave at first a greenish white precipitate; but this soon became quite white. The upper, clear liquid was almost colorless, only in the deeper portions a little touched with yellow.

The firm in question decided to use the process indicated under 10. The chemist recommended making three pits, in the first of which the water was to be treated with lime, and then with lime chloride and milk of lime. In the second the water coming from the first to be allowed to settle and then be filtered through 80 to 160 inches of sand into the third pit, from which it should either be let run into the Wildbach or be used again in the establishment.

The precipitate from the pits affords a good manure for wet meadows; is when dried an excellent disinfectant, and can also be used in the porcelain industr and for building purposes.

DISPOSAL OF COAL TAR.*

THE VALUE OF TAR AS A BY-PRODUCT.

BY CARROLL MILLER.

THE object of this article is to illustrate, in a condensed form, the value of tar as a by-product to both the gas and coke industries. The number of products which can be manufactured from coal tar, and the uses that may be made of them, being so numerous, the mentioning of a few of the most common will, I think, serve the purpose.

The demand for pitch and creosote, the largest products of distillation, seems to be increasing considerably; the former notably for briquette (patent fuel) making, the latter for preserving timber.

The growing demand for creosote may best be illustrated by quotations from the reports of Henry Grinnell, assistant forest inspector, who says, "The extraordinary increase in the use of the telephone and telegraph during the last few years (more than 2,650,000 a year), combined with the fast diminishing supply of timber used in pole-line construction, has led the telephone and telegraph companies to take great interest in experiments to find the best and most practical method for increasing the length of service of poles and crossarms."

According to Engineering News (January 23, 1908), 102,834,040 ties were purchased in 1906 by electric and steam railways. Of this number only about 12 per cent were treated.

Trautwine ("Engineer's Pocket Book") gives the life of untreated ties at from five to nine years. He says that creosoted ties have remained sound after twenty-two years. Lunge ("Coal Tar and Ammonia") writes: "Numerous specimens of creosoted timber have been found to be perfectly sound after being used as railway sleepers, fences, etc., for periods varying from 16 to 32 years."

The Department of Commerce and Labor states that 37,490,067,000 feet (board measure) of lumber were handled by sawmills during 1906.

By glancing at the above figures a fair idea may be had of the prospective demand for creosote, as this substance has proved to be the best for timber preserving, although crude tar is also successfully used. I have dwelt on this subject at some length for, aside from its interest to coal-tar producers, it is of extreme importance to many other industries.

Uses of Crude Tar.—(1) Paint, (2) fuel, (3) making and repairing roads, (4) preserving timber, (5) manufacture of roofing felt, (6) manufacture of lamp black, (7) gas making.

Distilling.—As the subject of distilling and refining tar is an extremely broad and lengthy one, I can here only touch on the generalities and will include but one purified product—naphthalene.

Simple Fractions of Distillation.—(1) Ammoniacal liquor, (2) light oil, including first runnings, (3) middle oil, (4) heavy oil, (5) anthracene, (6) pitch.

Distillation Products for Sale.—(1) Ammoniacal liquor, (2) light oil, (3) creosote (from 3, 4, and 5 in preceding list), (4) naphthalene (from 3 and 4 in preceding list), (5) pitch.

Utilization of Distillation Products.—1. The ammoniacal liquor is disposed of in the usual way. It might be here noted that sulphate of ammonia is manufactured at many gas and coke oven plants in Europe, at some of which the sulphuric acid is made from spent oxide.

2. Light oil.—Uses: Illuminating, enriching gas, mixing with pitch to make varnishes, mixing with anthracene oil to prevent the absorption of illuminants when washing gas to remove naphthalene; usually, however, light oil is rectified to make benzol and naphtha and in the production of aniline.

3. Creosote.—Uses: Gas making, varnish making, to soften hard pitch, antiseptic, and in preserving timber. When carbolic acid is extracted from middle oil, the residue is added to the creosote. Pyridine bases, which are used for denaturing alcohol, may be obtained from middle oil. Anthracene oil is used for extracting benzol from gas. Pure anthracene is obtained from the anthracene fraction.

4. Naphthalene.—Uses: Color making, making moth balls, burning for fuel and light.

5. Pitch.—Uses: Manufacture of briquettes (patent fuel), making varnish, roofing, roofing felt, making asphalt, road making and repairing, making lampblack, making coke, gas, etc.

An ordinary retort-house tar will yield on distillation about 220 gallons per 2,240-pound ton.

Yield of Tar by Distillation.—Ammoniacal liquor, 5 gallons; light oil, 6 gallons; creosote, 61 gallons; pure naphthalene, 90 pounds; pitch, 1,350 pounds.

The proportion of these products may vary considerably, depending on the temperature at which the coal is carbonized, the character of the coal, etc. Coke-oven tar may give about the same amounts of products as the above, but usually the percentage of pitch is less. Coke-oven tar contains but a small amount of carbolic acid. In appearance, tar from vertical retorts is similar to that from coke ovens.

During 1907, nearly 20,000,000 tons (2,000 pounds) of coke were produced in the Connellsville district, which would be equivalent to more than 25,000,000 tons of coal. If this coal were coked in by-product ovens, in addition to the coke, the following could be obtained: Gas, 750,000,000,000 cubic feet; tar, 170,000,000 gallons; ammonia, 130,000,000 pounds. Assuming 15 cents per 1,000 cubic feet for the gas, the equivalent in heat units of natural gas at 25 cents, 2½ cents per gallon for tar and 6 cents per pound for ammonia, the income from these three items would amount to $23,300,000, or nearly $1 per ton of coal. In order to be on the safe side, I have used low figures for both the amounts and values of the by-products. If the tar were distilled and sulphate of ammonia manufactured, larger profits would be realized.—Progressive Age.

* From a paper read before the New England Association of Gas Engineers.

ARTIFICIAL SILK.

A PAPER on the subject of artificial silk was read at a recent meeting of the Paris Civil Engineers' Society by M. E. Lamy, relating especially to the most recent progress in this field. Count de Chardonnet was one of the pioneers, and he established a factory at Besançon in 1891, but it was only after ten years of efforts that he and his collaborators were able to arrive at a process which would give an industrial silk. The Chardonnet process comprises three different stages. First, the preparation of the raw material; second, the drawing of the material into threads; third, the denitration process. The raw material used here is cellulose. Paper paste or cotton fiber properly prepared is employed. These are treated by a mixture of nitric and sulphuric acids heated to 40 deg. C. Pyroxyline or gun-cotton is thus produced and it is dissolved in a mixture of alcohol and ether. The greenish pasty mass which is thus formed is the well-known collodion, and it is used to form the threads. This latter process is carried out under a considerable pressure, through capillary glass tubes through which the collodion is forced. The tubes have a diameter of 0.10 to 0.20 mm. When coming out of the tubes the viscous thread is plunged into a suitable liquid where it is coagulated. The liquid employed here is a salt solution, acidulated water, or alcohol. The thread is then wound upon spools. In this condition the thread is brilliant like silk, but is very inflammable. In order to lessen this great disadvantage, the third or denitration process is employed. This operation consists in treating the thread by a solution of reducing agent which restores the thread to the state of cellulose. For this purpose are used hyposulphite of soda, or other products which secure the same result. The thread is afterward washed, then bleached and dried. Lastly, the dyeing of the thread is carried out in the same way as for cotton thread. According to the specimens of artificial silk which were shown to the society by the author coming from the Besançon and other factories, it has a great brilliancy, but the resistance, especially in a damp state, is not nearly as high as that of natural silk. This is a great disadvantage which is found with all the artificial silks, and up to the present all efforts to overcome it have been unavailing. Following the erection of the Chardonnet works, the artificial silk process has been taken up in different countries of Europe, and there are now seven or eight factories in operation for this purpose. Among the numerous processes which are used at present, some of which have been patented, there are only two which seem capable of a real industrial application. These are the cupro-ammoniacal process and the xanthate of cellulose process. The cupro-ammoniacal process is as follows: The cellulose, properly prepared (generally formed from cotton waste), is dissolved in a solution of copper and ammonia, then passed in the tubes above mentioned for forming the threads, and it is precipitated directly by an acid under the form of a filament which does not need to be given any other chemical treatment. The resulting thread is brilliant and has some resistance, and it is a good industrial product. Its price is lower than the thread of the Chardonnet process. M. Lamy showed samples of this product which is made at the Givet factory. It is known as "Parisian silk." In the second process which is now in use, the solution for producing the silk is obtained by treating the cellulose with carbon disulphide, and we thus obtain a product which when dissolved in water or alkaline liquids gives a solution known as "viscose." The viscose is sent directly through the tubes, and on leaving these the filament is plunged into a bath composed of sulphuric acid, sulphate of ammonia and sulphate of soda, which is heated to 50 deg. C. Then it is washed in water and dried under tension at a temperature below 80 deg. C. The thread is then passed in a tepid solution of sulphide of sodium, then washed, bleached, and dried. Viscose silk has the same qualities and the same defects as the preceding. Its cost appears to be less. Some interesting samples of viscose silk were also shown to the society. In order to increase the tenacity of the silks, especially in the wet state, a number of processes have been proposed, but none of these has given much satisfaction up to the present. It is stated, however, that the new process invented by M. Eschalier, of Lyons, and known as "sthenosage," has given good results.

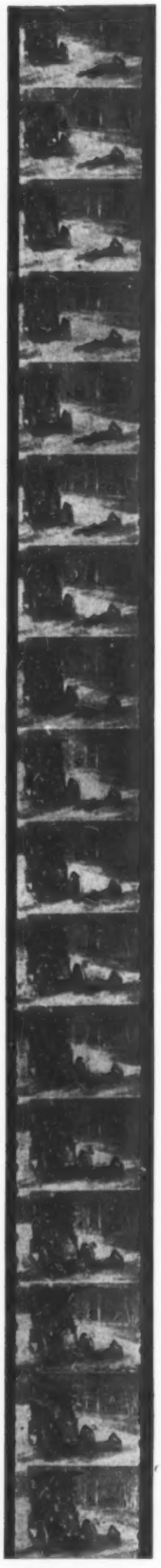
To sum up, the artificial silk threads are produced at present by the processes above mentioned, the nitro-cellulose, cupro-ammoniacal, and viscose, and the resulting products give silky threads, which for some purposes can be substituted for natural silk. They are more brilliant than the latter, but are less supple and feel different to the touch. Their capital fault is to have a less tenacity, especially in the humid state. Another drawback is that their specific gravity is higher by ten per cent than real silk, so that for the same total weight the woven surface is less. It is expected that in the future these defects will be remedied and in this case there will be a great use for the new product. In the different factories of Europe there are already produced 3,300 tons annually, in which the nitro-cellulose silk figures for 1,600 tons, the cupro-ammoniacal silk for 1,200 tons, and the viscose silk for 500 tons. France produces a total of 660 tons for the three kinds. The cost of manufacture varies according to the process from $4 to $6 per pound. Specimens were shown by M. Lamy consisting of various woven stuffs, braids, fringes, gauze, and furniture stuffs. These are in some cases mixed with natural silk, cotton, or wool.

Experiments are being conducted on a new water softener designed by A. R. Holmen of the Pennsylvania Railroad, and built by the Southwest system of that road at the shops in Indianapolis. This plant has a capacity of 30,000 gallons per hour and consists of a settling tank or clear well, a mixing drum, a solution tank with lime-slaking tank above, an adjustable solution pump, and a water motor, with the necessary piping. The water motor operates stirring apparatus in the mixing drum and in the solution tank; also the solution pump. In operation the raw water first passes through and operates the motor, for each revolution of which the solution pump makes one stroke. The length of stroke and strength of the solution, which at Indianapolis contains lime and soda ash, are so adjusted that the necessary amount of chemicals is thus pumped into the raw water. The chemicals meet the raw water as it passes from the motor to the mixing drum and the two are combined by agitation in this drum for about one minute, when they pass from this through a pipe to a bell in the settling tank. Under the lower edge of this bell the water passes into the settling tank, in which it rises and flows off at the top through an overflow pipe to the storage tanks. The thorough mixing of the water and chemicals under pressure hastens the chemical action so that it is completed before leaving the bell, and also crowds together the precipitant into a more compact form, resulting in a quick and very complete clarification. The sludge is removed by a system of pipes located in the bottom of the settling tank and connected to the waste discharge. Raw water can be admitted by a by-pass directly into the settling tank for stirring up the sludge. Filters have not been used, as it was thought that the settling of the precipitant would be complete, but arrangements have been made for sand filters if their use is thought desirable. This plant has been in operation for eight months with most satisfactory results.—Municipal Journal and Engineer.

THE MAKING OF MOVING PICTURES.—I.

HOW THEIR FANTASTIC EFFECTS ARE OBTAINED.

BY GUSTAVE BABIN.



The Automobile Accident.

FEW inventions have made, in the beginning, an impression equal to that produced by the cinematograph, or moving picture apparatus. Not one, perhaps, has enjoyed so great and so long a popularity. Every one remembers the amazement which he experienced when for the first time he saw projected in successive quivering pictures on the white screen movement, life itself, caught, fixed, and then revivified by the cinematograph. For myself the memory of my first acquaintance with this marvel will always be ineffaceable. It was in an improvised theater in a basement, a few days after the first public exhibition of moving pictures in France. The programme was ridiculously simple. Employees leaving the Lumière factory, the start of a railway train, the debarkation of passengers from a steamboat; and the comic relief was given by the "Sprinkler sprinkled," which soon became very popular. Since then the moving picture has progressed with remarkable rapidity. The moving pictures have moved from the basement and conquered the theaters in all parts of the world. For a few cents one can witness miracles.

A milliner's apprentice taking a nap on a bench is suddenly transformed into a fashionably-dressed lady; in the middle of an avenue a sleeping sot is cut in two by an automobile and then put together again; clowns mount stairs backward and make amazing leaps; an omnibus goes backward, dragging the horses after it; pumpkins roll up a hilly street and bound into upper windows; a ski runner darts through the

The Cripple Brandishing the False Legs After the Accident.

Substitution of the Cripple and the Artificial Legs for the Other Actor.

The Severed Legs Are Replaced and Healer and Healed Shake Hands. The Left-Hand Scene is Enacted by the Cripple; the Right-Hand Scene by the Other Actor.

The Two Actors "Making Up" for a Moving Picture Episode.

The Cinematograph at Work at the Critical Moment.

THE AUTOMOBILE ACCIDENT.

air, strikes against a factory chimney, knocks it down and continues on his course, skating over the clouds. From a bunch of scattered roses springs a swarm of imps or of dancing girls; in a shady park under willows quivering in the wind a column of vapor arises and becomes transformed into a radiant vision which smiles, dances, in short, lives. In a wall or in the silky tissue of a Persian rug appears a vague spectral feminine form, which gradually becomes definite, advances, performs a pantomime, a dance, and then melts into thin air.

How is all this done? We cannot here explain all these marvels in moving pictures. Every establishment has its own peculiar methods, but there is no great secret, and the artifices by which the astonishing effects are obtained are really few and simple. When he has learned the principal and commonest devices, any attentive spectator ought to be able to understand nearly all the mysterious effects of moving pictures. The details here given were furnished by M. Léon Gaumont, the director of one of the largest establishments for the production of moving picture fixtures.

Moving pictures may be divided into two great classes. First, scenes taken directly from nature, reproductions of festivals, processions, views of various countries, etc.; secondly, theatrical scenes, dramatic or comic pantomimes, fairy scenes, constructed according to the rules of dramatic art. But the combination of these two classes, the transference to a natural scene of theatrical compositions interpreted by actors, mingling the real with the factitious, giving to fairy tales a background of real fields, forests, mountain and surf, and also the employment of means which are peculiar to the apparatus itself, allow us to obtain most wonderful effects, quite impossible and unknown until now. The reproduction of actual scenes constituted at first almost the entire domain of the cinematograph. By constantly improving the methods, astonishing results have been obtained in this class of work. For example, the funeral of King

Snapshot Showing How the Policemen's Swords Are Pulled Toward Him With Cords.

Pursued by a Manhole Cover. The Cover is Made of Wood and Moved by Cords. (From a moving picture film.)

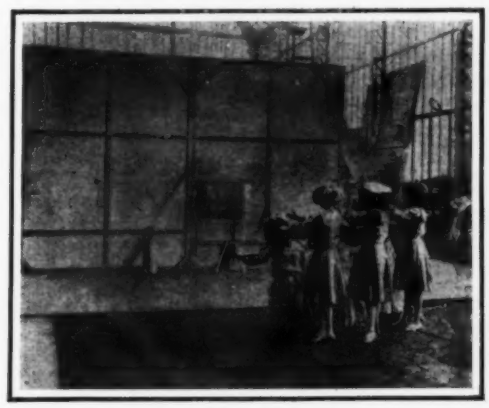
Attacked by a Lamp Post. The Post is Moved by Cords. (From a moving picture film.)

THE MAGNETIC GENTLEMAN.

THE TRAVELING BED

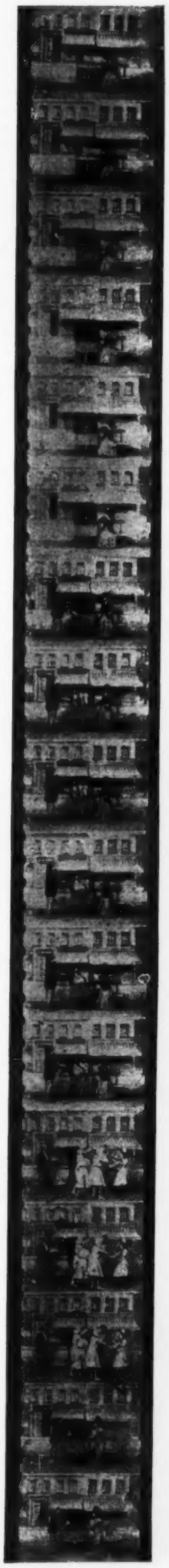
Carlos of Portugal took place at Lisbon on February 8, 1908; three days later, on the 11th, spectators in Paris and London saw moving over the screen the painted and gilded coaches of the ambassadors, the gorgeously-clad red archers, and the black funeral cars of the King and the Prince. Most of this delay was due to the slowness of the locomotive. At Lisbon the spectacle might have been produced on the same evening, an hour after the termination of the ceremony. With the processes of developing and printing which are now used, it is possible to project a film twenty minutes after it was taken. But the field

Removal of the Box Cover and Part of the Back Scene During a Stoppage of the Apparatus.



The Dancing Girls as They Appear from the Back of the Stage.

The Dancing Girls Take Their Positions at the Back of the Deep Stage and Are Seen Through the Hole Which Represents the Box Cover. Their Distance Makes Them Appear Very Small.



The Old Beau Comes Out of the Milliner's Box, Followed by Fairies Offering Rich Garments and Gems. (From a moving picture film.)

THE LITTLE MILLINER'S DREAM.

for this class of work is very limited, for it is necessary to wait for events to happen. The theatrical field, on the contrary, is unlimited, being incessantly extended by the imagination of librettists and the ingenuity of mechanicians and operators. The public, which delights in seeing the scenes of a comedy or tragedy projected on the screen in a few minutes, has no idea of the amount of work and of money that the smallest of the dramas thus represented has cost.

A new career has opened for ambitious budding dramatists, who are generally very well received by the picture makers, for who knows that they may have in their minds the unknown masterpiece, the inspiration, the subject of a film, which will be sold throughout the world by thousands of miles? On the other hand, the aspirant is often cut short with the curt remark: "Oh, that's old."

The idea having been accepted, the next thing to be done is to mount it, exactly as in an ordinary theater, and to enact it as well as possible. The theater of Belleville, where all this work is done, has its actors and actresses, its scene painters, and the entire personnel of a theater. It has also all the mechanical devices of a complete theater, with numerous stage galleries, and three stories below the stage. Here the writer saw the preparation of the moving picture film entitled "The Little Milliner's Dream." In the first scene appears a little milliner's apprentice, cheaply but coquettishly dressed; she has left her suburban home in the morning and is now hard at work, with the inevitable immense box under her arm. But as she stops to look into a jeweler's window she suffers, as so many others have done, the delicate attentions of an elderly gallant. She shrugs her shoulders and goes on her way, forgetting the sparkling jewels. However, she cannot banish the memory of this incident. As she walks on, she keeps thinking of this engaging gentleman, and when, overcome with heat and fatigue, she sits down on a bench and falls asleep, she has a dream in which he plays the principal part. Her box lying on the bench beside her has mysteriously opened, and from the top, lined with black plush, suddenly appears a little figure, hat in hand, bowing and smiling, the miniature image of the old beau of the street. He comes forward, increasing in size, bows very low, and renews his homage. The girl cannot believe the evidence of her eyes, and the spectators experience a similar difficulty.

This miracle is accomplished by very simple means. In the first place, the background is of an artificial and theatrical character. The back of the bench is not real, but is painted on canvas. Immediately over the box a hole is cut in this canvas of the exact size and shape of the box cover. At the beginning of the dream the moving picture apparatus is stopped; then two men take away the box cover, exposing a window opening upon a black background, formed by an immense black canvas at the back of the deep stage. Because of the perfect similarity of surface and color, the spectator has no idea that the box cover has been removed. In this rectangular field, in the extreme background, the old beau has taken his position during the stoppage of the apparatus.

The apparatus is now started again, and the action is resumed. The girl is now all attention and the gallant all attention. The apparatus takes up the action at the exact point of the scene and of the film at which it had stopped, so perfectly that there is not the slightest indication that any interruption has taken place. Here, then, we have an artifice peculiar to the apparatus, namely, the pause; and the applications of this are innumerable. The entire action and effect of the milliner's dream are based upon this device.

Taking advantage of a second pause, the old beau comes in front of the back scene, walks forward, and attains life size. At a gesture of his a flock of miniature dancing girls now appears in the box cover, from which he has just emerged. They appear very small because they are in the extreme background. As they dance they move forward and gradually increase in size, owing to the effect of perspective, exaggerated by the distortion of the lens as in all photographs; and when at last they have become near enough to fill the opening, the apparatus is stopped again and the girls come in front of the scene, repeat the pantomime of the gentleman, and kneel at the feet of the astonished apprentice. One presents her with a hat of the latest fashion, another with an elegant costume, and still others with jewels. In another instant we behold her, adorned with these works of art; her shoulders gleaming with pearls, her wrists encircled with bracelets, in short, appareled for the ball. This metamorphosis was accomplished by means of another pause, apparently instantaneous.

The little milliner, captivated by all this, goes off with the gentleman, who very politely takes the big box under his arm, but very wisely drops it at the next corner. As it strikes the pavement it is transformed, by means of another pause, into a fine automobile, in which the couple take their seats. The following pictures show the little milliner surrounded by a gay company, dining and wining. Suddenly part of the scenery changes to that of the first act, and she sees a vision of her parents, seated before the lighted lamp, anxious and weeping because of her non-appearance at this late hour. She starts to speak to them and embrace them, when they suddenly change into two of her fellow guests. Finally we see her on her bench in the park, rudely awakened by a policeman.

This artifice of the pause, which we have seen used so often in this single film, is the means of producing the most surprising effects. The transformation of a flower into a woman, in general the substitution of any person or object for another, is accomplished in this way, and the illusion is so perfect that the older stage devices of gauze and mirrors, the vision of Marguerite in Faust, for example, appear very crude in comparison.

A pause followed by a substitution of persons is the chief machinery of the "Automobile Accident," one of the most startling of all the series. Here the action takes place, not in the theater but in the highway. The difficulty is to obtain the principal actor, and it is more difficult to induce him to play his part than it is to find him. Here is the story:

A gentleman much the worse for wine is tacking up the road when he comes to a sudden stop, falls down, and falls asleep. Along comes an automobile at high speed, which runs over the sleeper and cuts off his legs above the knees. He wakes up, lifts up his legs, one in each hand, and drags himself, like a wounded frog, after the vehicle. This finally stops, and a stolid passenger dismounts. He calmly takes out of the car the repair kit, in a few seconds he replaces the severed legs, and he and the patient shake hands and part excellent friends. Now all this is easily done with the aid of the pause and a legless cripple. The legless cripple, as I have said, is hard to find and still harder to engage. This principal actor having been obtained, a second actor with perfect legs makes up in exact imitation of the cripple. With these two men and two artificial legs we proceeded to the Park of Vincennes. The apparatus having been set up, the second actor began the scene by staggering along the road and falling down. The apparatus was then stopped, and during the pause the automobile moved very slowly until the front wheel touched the sleeper's legs, leaving on the road a trace of its path.

The place where the drunkard had lain was also marked, the cripple was substituted for him and completed by the addition of the false legs, disposed as ingeniously as possible. The automobile, which had been removed, now returned, following exactly in its former tracks, the cinematograph having now been started. As the car ran swiftly up to the man I think all of us shuddered, but everything went well, and the cripple sat up, brandishing his severed legs. The rest of the scene was not photographed that day, and for this reason the pictures of it here reproduced show different actors. Of course, the automobilist applies the artificial legs to the cripple's stumps, and then another pause allows the second actor to be substituted for the cripple.

The very lively impression which this scene produces results in large part from the environment in which it takes place, the real landscape which surrounds it, and which at first prevents us from imagining the possibility of deception. This is the case, also, with the "Magnetic Gentleman," of which, however, some scenes occur in the theater and some in the street. The hero of the story, having been attacked by "Apaches" (Parisian thugs), resolves to provide himself with a suit of mail. The boys who were sent to take it home, unfortunately stop at an electrical establishment and lay the package on the frame of a dynamo. The armor becomes magnetized, and is removed with difficulty. Tin cans and the cars containing them pursue the boys as they carry it away. When the gentleman puts on the armor, his breakfast platter leaps from the hands of the maid and sticks to his shoulder; he goes out of the house, and misfortune pursues him. He cannot pass near an iron object without attracting it; milk cans, tin signs, etc., rain upon him, a manhole cover jumps up and rolls after him, and the lamppost descends upon his head. He is arrested and taken to the police station, where the sabers of the gendarmes spontaneously turn against him. In this series no tricks peculiar to the apparatus are employed. The objects are moved by wires or directly by human hands.

The mystery of the moving bed in which the evicted tenant is conveyed from street to street is still more simple, for it is merely pushed along by two men concealed behind it. The mystery and interest consist in the appearance of the bed in the middle of a crowded street.

In the following article we shall see other examples of effects of this kind, produced by the combination of natural scenes with theatrical actions, and we shall learn that still stranger effects can be obtained by special methods of taking the pictures and treating the films.—Translated for SCIENTIFIC AMERICAN SUPPLEMENT from L'Illustration.

(To be concluded.)

A STATISTICAL STUDY OF MIDSUMMER BIRDS OF ILLINOIS.

S. A. FORBES, of the University of Illinois, has prepared a paper which contains a preliminary statement of some of the more general results of a census of summer resident birds of Illinois, giving the entire bird population of a strip 150 feet in width and 428 miles long (12 square miles), one-third of this area being in southern, one-fourth in central, and two-fifths in northern Illinois. The method of the enumeration was such as to give the numbers of each species found on measured areas, taken at random, of each crop or other distinguishable kind of surface. The responsible observer, Mr. A. O. Gross, determined 7,740 birds belonging to 85 species—an average of 645 birds to the square mile, of which 18 per cent were English sparrows. On this basis, the total summer population of the State numbers about 30,750,000 birds, of which five and a half millions were English sparrows. Eighty-five per cent of these birds belonged to one-fourth of the species. The ten most abundant species, and the numbers seen of each, were as follows: English sparrow, 1,414; meadow-lark, 1,025; bronzed grackle, 900; mourning-dove, 461; dickcissel, 393; red-winged blackbird, 347; prairie horned lark, 296; flicker, 197; robin, 194; and field sparrow, 186.

The English sparrows decreased in numbers per square mile from north to south (perhaps because of a diminishing population southward and a consequent progressive diminution of their breeding areas), 100 sparrows in northern Illinois being represented by 77 in central and 56 in southern; but the native birds increased from north to south, apparently for climatic reasons—100 in northern Illinois being represented by 116 in central and 129 in southern. The same gradation was still more pronounced in winter residents, which averaged 384 birds to the square mile in northern, 582 in central and 832 in southern Illinois. The general average for the whole State and the entire year, as represented by 1,591 miles of travel and a census area of 44¼ square miles, was 722 birds to the square mile.

By comparison of the midsummer numbers with the average for the fall migration period, a wave of denser population was detected, running from north to south and rising with the progress of the migration. The central Illinois average for October was 2.3 times that for July, August, and early September.

The original relation of the Illinois bird fauna to prairies was still discernible in the fact that half of these summer birds were found in pastures and meadows, although only a little over a third of the area inspected was in grass. Corn fields, on the other hand, which covered 32 per cent of the area, contained but 15 per cent of the birds, and these most largely English sparrows.

As an example of the local and numerical distribution of species, that of the meadow-lark was given, and as an example of the composition of the bird fauna of an ecological situation, the birds of the pasture were separately discussed. Meadow-larks, while numbering 85 to the square mile for the whole area covered, were very unequally distributed, averaging 266 to the square mile in fields of stubble, 205 in meadows, 144 in pastures, and 10 in corn fields, and not occurring at all in forests or among shrubbery. They increased notably in number from north to south—100 in northern Illinois being represented by 175 in central and 215 in southern.

Pasture lands were the preferred resort of the most abundant midsummer species, and contained 27 per cent of all the birds seen. In average density of population, however, they were surpassed by meadows, which contained 920 for each square mile, to 878 in pastures, 562 in stubble and small grain, and 300 in fields of corn. The commonest pasture birds were the English sparrow, the crow-blackbird, the meadow-lark, the horned lark, and the field sparrow, abundant in the order named, and together making more than half the summer residents of the pasture lands of the State.

The impression made by this general examination of the present bird population of the State of Illinois was that of a remarkable flexibility and tenacity of the associate and ecological relationships of birds in the face of revolutionary changes in their environment. Apart from the results of the introduction of the English sparrow, and the direct destruction of game birds and birds of prey, the main effect of human occupation seems to have been the withdrawal of most of the prairie birds from the area devoted to Indian corn, and their concentration in pastures, meadows, and fields of small grain—situations which most nearly resemble their original habitat.—Science.

In lieu of a cedar chest, pieces of wood soaked in cedar oil and laid in drawers and closets will be almost as satisfactory.—Good Housekeeping.

MATHEMATICAL PRODIGIES.

AN EXPLANATION OF ARITHMETICAL PRECOCITY.

AN exhaustive study of mathematical prodigies by Frank D. Mitchell, published in the American Journal of Psychology, may be thus partially summarized:

A fairly complete list is presented of the more important prodigies on record, with those data in each case which shed most light on the nature and development of the calculating power. An effort is also made to correct several errors which have crept into the literature, and to bring out a few points whose significance has been overlooked; so that the present account, it is hoped, will be found reasonably complete and reliable. In particular, the case of Zerah Colburn has been entered into in some detail.

A new case is described, that of Mr. Mitchell himself. The calculating power is in this case very slight, and in itself unimportant. It has been described at some length, however, to bring out the naturalness of the "precocity" involved, the gradualness of the development of the calculating power, the important part played by counting—first in the series of natural numbers, and later in the series of multiples and powers of various numbers—the general character of the numerical properties brought to light in this way—properties which awaken the interest of the calculator, furnish the motive for continued practice, and shorten the labor of calculation, rendering the whole process self-sufficient and independent of outside aid—and, to some extent, the nature of the psychological and mathematical processes and short-cuts used in this particular case. The part played by "2-figure endings" has been entered into in some detail, as shedding light on a class of problems—evolution and factoring—which have often puzzled students of the subject, owing to the surprising rapidity with which some of the prodigies have solved them. In none of these respects is the material here presented wholly new. Most of it, perhaps, could be deduced from a careful study of Bidder's case. At the same time, it remains true that the significance of these facts has *not* been fully brought out by previous investigators; hence it has seemed worth while to dwell on them here at greater length than would otherwise be necessary.

The data thus collected have been studied and conclusions drawn under several heads. Attention has in the main been confined to the "natural" calculators who develop spontaneously, at least in the first instance, without external aid from books and teachers; as distinguished from the "artificial" calculators who use external aids from the start. Huber's blind Swiss is perhaps the only "artificial" calculator here considered; but the distinction must not be too sharply drawn, since several of the others have made use of "artificial" methods, such as mnemonic systems. A calculator may begin in the "natural" way, but later make use of "artificial" methods besides, in order to extend his calculations further, as Gauss did in his use of logarithms; if the younger Bidder had any "natural" gift to start with—a question we must here leave open—he belongs to the same class with Gauss in this respect. In general, it is obvious that skill in calculation attained by using these "artificial" methods, either from the start or at a later stage, constitutes no special problem for the psychology of mathematical precocity, belonging rather to the psychology of deliberately practised operations in general, and hence need not be discussed in such a study as the present.

Into the question of heredity in mental calculation we have not attempted to enter, not only because of the scarcity and uncertainty of the data, but because such general terms as heredity and environment do not carry us far in the study of any special function, like mental calculation.

Precocity in calculation is natural and normal; not only is the popular amazement over it groundless, but there is no need even to regard it as "remarkable." Owing to the origin of mental calculation in ordinary counting, and the complete independence and self-sufficiency of mental arithmetic, mere mathematical precocity falls in a different class from musical precocity, and still more from the all-round precocity shown by such men as Ampère and Macaulay. If for any reason the mathematical prodigy loses his interest in calculation, or the opportunity to practise it, his power is likely to diminish or eventually to disappear; in this respect mental calculation is like piano-playing, or any other highly specialized activity dependent on long practice.

Skill in mental calculation is, owing to the isolation of mental arithmetic already noted, independent of general *education;* the mathematical prodigy may be illiterate or even densely stupid, or he may be an all-round prodigy and veritable genius. Furthermore, mental calculation is entirely independent of *mathematical* ability and education; the calculator may never rise above the counting stage, or may acquire merely arithmetical skill, or may develop a keen insight into algebraic relations, or even, like Safford and Gauss, a marked aptitude for higher mathematics. Hence it is not helpful to classify the mathematical prodigies either by general education or by subsequent mathematical development. Indirectly, however, ignorance favors a high development of the calculating power, by preventing other and more important interests from taking its place. Where the power *is* retained in spite of the widening of interests, its practical value may become considerable, especially to the mathematician, the lawyer, or the engineer.

Although mental arithmetic naturally develops out of *counting*, the fundamental operation is *multiplication*. This operation may remain permanently in the counting stage, i. e., may proceed without the use of a memorized multiplication table; usually, however, a multiplication table up to 10 x 10 is used. Many of the prodigies begin at the left in both multiplication and addition. Proctor describes in his own case a method by the aid of visual dot-patterns, but no other calculator is known to have followed this method. Two of the visual calculators, Diamandi and the younger Bidder, used cross-multiplication. The theory has been proposed that a large multiplication table, perhaps to 100 x 100, is used by some of the prodigies; but there is no evidence that any of them actually did use such a table, and even Dase's feats are explicable without presupposing it. Problems in square and cube root (especially of exact squares and cubes) and factoring are favorites with some of the calculators; in those cases where the answer is given "instantly," the simple properties of 2-figure endings are used.

Various mathematical and psychological *short-cuts* explain the speed attained by some of the prodigies in their mental operations. Problems done "instantly" are either very simple, or else are solved by guess and trial, with the aid of little tricks and properties readily discovered by the calculator. Many algebraic problems are thus solved, and the same is true of square and cube roots of perfect squares and cubes, as we have just seen.

The distinction which is so often made between *memory* and *calculation*, with the implication that the great calculator is simply a little calculator with a big memory, using the same methods as his lesser rivals, is misleading; the process is always (in the "natural" calculators) a true calculation, and memory for figures is important only in so far as it stands in the service of calculation.

Finally many of the calculators heretofore supposed to be of visual *memory type* turn out, on closer examination, to belong to the auditory (or auditory-motor) type, at least in calculation; and, in general, since counting is essentially a verbal process, the calculator who begins from counting, before he learns to read and write, will usually belong to the auditory type, and will make relatively little use of visual images in his actual calculations. At least two of the "major" prodigies, however, and possibly four, belong to the visual type.

METHODS OF FIREPROOFING WOOD AND TEXTILE FABRICS.

THE substances which are applied to wood and fabrics for the purpose of making them less inflammable are, for the most part, non-volatile mineral salts which are nearly or quite infusible and neither deliquescent nor hygroscopic. Solutions of these salts, usually mixed with adhesive substances, are applied either by dipping or with the brush.

The salts most commonly employed are the phosphates, tungstates, and borates of ammonia and the alkalies, the chlorides of calcium, magnesium and zinc, and the silicate of sodium. According to M. Lochtin, precipitated alumina and the silicate, phosphate, and chloride of ammonium are the most efficacious in practice. The ammoniacal salts, when dissociated and partially volatilized by heat, leave residues which are entirely incombustible. The action of alumina, on the other hand, is purely mechanical.

For textile fabrics the simplest process consists in soaking them in a ten per cent solution of ammonium phosphate, wringing and drying in the open air.

For wooden sheds, partitions, boxes, and casks the application of one or several coats of a ten per cent solution of sodium silicate is usually deemed sufficient. Mixtures of asbestos with glycerine or solution of sodium silicate are also applied to wood for the purpose of retarding combustion.

Unfortunately the effect of all these applications is only temporary. The added substances gradually disintegrate and fall away in the form of dust under the influence of the atmosphere.

For textile fabrics no more radical method of fireproofing appears possible, but in the case of wood attempts have been made to incorporate the fireproofing agent more intimately with the fibers. For this purpose exposure to superheated steam has been recommended and experience has proved that this treatment greatly facilitates the absorption of the fireproofing substance. The duration of the treatment varies with the character of the wood, from four hours for the softest woods to two or three days for the hardest.

A company has been organized in England and America for the preparation of incombustible wood for use in warships. The following process is employed. The volatile and putrescible ingredients of the wood are first eliminated by roasting it in drums and the wood is then saturated, under a pressure of 200 pounds per square inch, with a solution of which the principal active constituent is ammonium phosphate. The operation occupies four hours. The wood is then dried for two weeks. Wood treated by this process exhibits remarkable fire-resisting qualities and it has been adopted by the navies of Great Britain and the United States.—La Science au XXme Siècle.

THE AERODROMOMETER.

IN the course of a research into the respiratory movements, Prof. Zwaardemaker, of Utrecht, has devised a very simple apparatus for determining the velocity of gas streams, an apparatus which seems to be capable of application for mechanical as well as for physiological experiments. This aerodromometer consists of a vertical glass tube, about 25 centimeters in length and 1 or 2 centimeters in diameter, in the middle of which a disk of aluminium is suspended by two spiral springs attached to the extremities of the tube. The air enters above through a number of inlet openings which take up nearly the whole of the cross-section of the tube. The aluminium disk does not completely bar the passage, and an annular clearance is left between the disk and the cylindrical glass walls. When experimenting on the breath, the clearance is made rather wide—as much as 2.5 millimeters—not to obstruct the breath, which is very sensitive to any impediment. When more powerful air currents are to be measured, the clearance may be reduced to 0.5 millimeter, and the sensitiveness of the apparatus thereby be increased. The instrument is empirically gaged by means of a constant air current, produced, for instance, with the aid of a water-jet pump or an electric fan or blower; for the apparatus answers both for suction and pressure observations. The aerodromometer itself checks the constancy of the air-current to be measured. The deflections of the disk depend upon the velocity of the air-currents and upon the apparatus and its dimensions. Using a tube with six inlet openings aggregating 0.93 square centimeter, and a clearance of 0.44 square centimeter, Zwaardemaker, as he reports in the Zeitschrift für Instrumentenkunde, observed the following deflections measured in millimeters, with air volumes measured in cubic centimeters per second: 1 millimeter, 12 cubic centimeters; 2 millimeters, 23 cubic centimeters; 3 millimeters, 35 cubic centimeters; 4 millimeters, 46 cubic centimeters; 5 millimeters, 58 cubic centimeters; 10 millimeters, 86 cubic centimeters; 15 millimeters, 105 cubic centimeters; 20 millimeters, 121 cubic centimeters; 30 millimeters, 154 cubic centimeters; 40 millimeters, 179 cubic centimeters; 50 millimeters, 200 cubic centimeters. Another apparatus fitted with an aluminium disk 1.4 centimeters in diameter, leaving an annular clearance of 1.5 square centimeters, gave: 1 millimeter, 60 cubic centimeters; 5 millimeters, 189 cubic centimeters; 10 millimeters, 288 cubic centimeters; 15 millimeters, 360 cubic centimeters; 20 millimeters, 417 cubic centimeters; 30 millimeters, 516 cubic centimeters; 40 millimeters, 597 cubic centimeters. Further tests have been made with the aid of J. T. van Have's breath-volume recorder, an instrument described three years ago. Two of these latter instruments were placed on the two sides of a pendulum, 2.3 meters in length, in such a way that each oscillation of the pendulum sent an air-current through the Have instrument, which recorded the air-volumes. Each of these instruments was connected with an aerodromometer, whose oscillations were likewise photographically recorded. In this way two synchronous curves were obtained: a volume curve of the sine type, and a velocity curve of the cosine type. The two curves were found to be in complete accord, and it would thus appear that the aerodromometer is suited for recording the velocities of air-currents alternating in direction at a fairly rapid rate.

A NOVEL COOLING INSTALLATION.

A SUGGESTION FOR THE TROPICS.

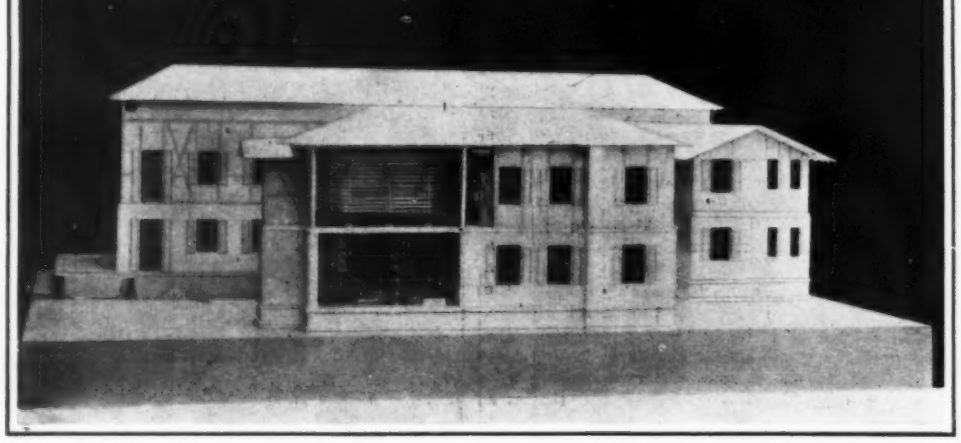
BY DR. A. GRADENWITZ.

THE humid heat of many tropical places has always been a serious bar to colonization by northern people, whether European or American. Men temporarily living in such places may be classed as invalids; they are unable to perform regular physical work, and as overseers or directors fall into a languid habit. This problem of the tropics is one which has received but haphazard attention; people dress lightly, feed lightly, and by resting during the hot hours, and installing fans or punkahs in their houses, endeavor to pass the time with a minimum of discomfort; but little systematic attempt has been made toward a definite amelioration of conditions.

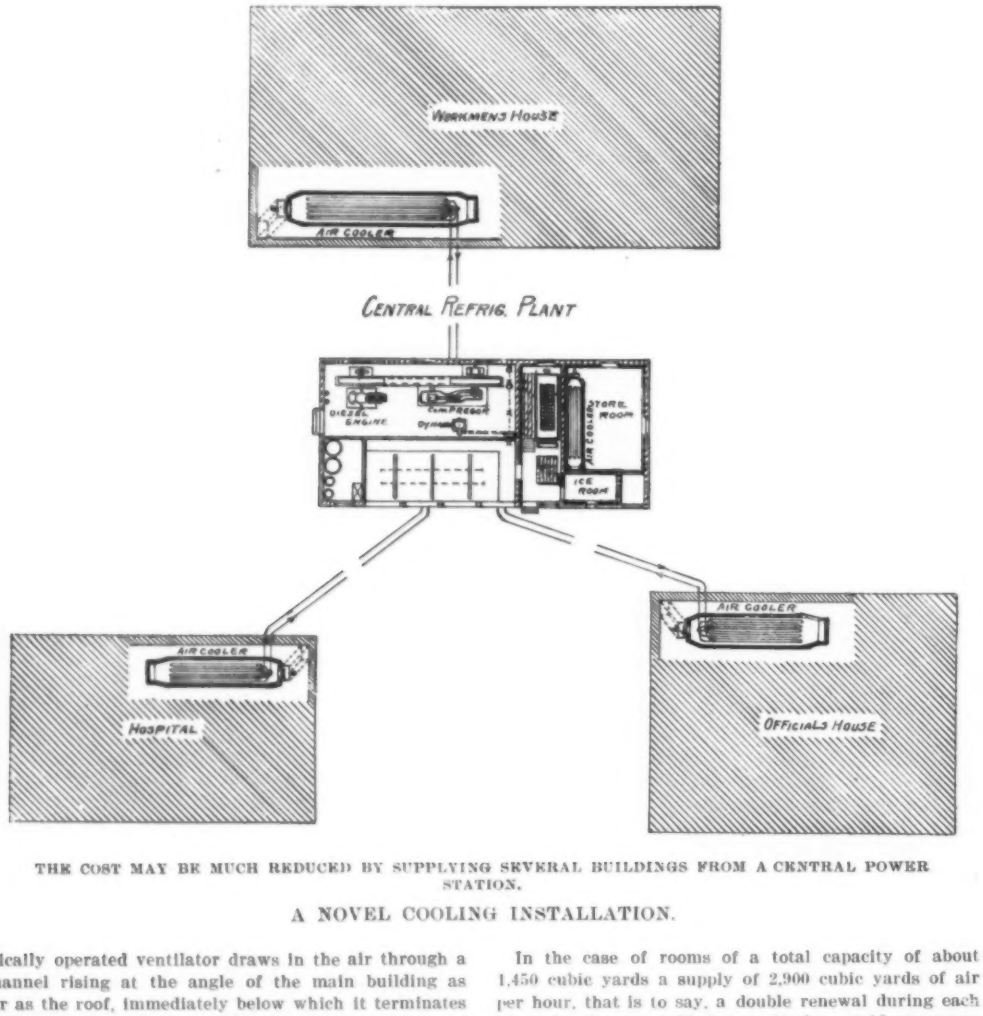
An interesting attempt to provide a refreshing coolness in a hot country has recently been made by Prof. Linde, of Munich, who has designed a refrigerating plant for the Nachtigal Hospital at Togo, in German West Africa.

The hospital itself was constructed on the lines usual in the tropics, ventilation being insured only by natural means through doors and windows, without any mechanical refrigerating and ventilating plant. The new refrigerating plant is intended, first, for ventilating all the rooms of the main building, according to actual requirements with sufficient amounts of dried and cooled fresh air; secondly, for manufacturing ice; and, thirdly, for refrigerating a store room for provisions.

The refrigerating machine, designed on the Linde system, is located in a wing containing the kitchen. The ammonia compressor, the Diesel motor serving to operate the latter, and a dynamo are situated in the ground floor, and the condenser (worked if desired with sea-water), as well as the ice generator and an ice reservoir, are located immediately above in the upper story. The dynamo supplies current for actuating the fresh-water pump and the ventilator, while providing for the electric lighting of the building. The apparatus for drying and cooling the air is located below the veranda and is made up of wrought-iron coils, in which the ammonia is vaporized. An electrically operated ventilator draws in the air through a channel rising at the angle of the main building as far as the roof, immediately below which it terminates into the open. The air being thrown along the pipe system will yield to the latter its warmth and moisture. The dried and cooled air then passes through a vertical main pressure channel into two horizontal channels which are carried in each story the whole length of the building. From these channels the air passes to the ventilators opening into the various rooms. The cooled air enters at the ceiling with very low speed and mixes immediately with the warm surrounding air, any draft being thus avoided. The escaping air leaves through small fissures in the doors and windows or special egress may be arranged. In the place of individual ventilators, a perfectly uniform distribution of the entering air can, if desired, be effected in each room by conducting the air into the whole empty space of the ceiling, the latter being provided with discharge openings throughout its surface.



MODEL OF A HOSPITAL AT TOGO IN GERMAN WEST AFRICA, SHOWING THE COOLING INSTALLATION.



THE COST MAY BE MUCH REDUCED BY SUPPLYING SEVERAL BUILDINGS FROM A CENTRAL POWER STATION.

A NOVEL COOLING INSTALLATION.

In the case of rooms of a total capacity of about 1,450 cubic yards a supply of 2,900 cubic yards of air per hour, that is to say, a double renewal during each hour, has been provided for. If the outside temperature be 84 deg. F. and the moisture 80 per cent, on the air being cooled down to 61 deg. F., 10 gallons of water will be precipitated during each hour from the 2,900 cubic yards of air, about 10,000 heat units being used up for cooling and 14,000 heat units for drying, that is to say, an aggregate of about 24,000 heat units, which is to be yielded by the refrigerating machine. By introducing the cold air, the temperature of the room, allowing about 7,000 heat units per hour for cold losses, will be adjusted to about 8 deg. F. below the outside temperature; that is to say, to about 76 deg. F. The losses just referred to are mainly due to heat introduced through the walls, floor and ceiling surfaces, or developed by persons dwelling in the house, or strong winds or through opened or badly closing windows and doors. These losses should be reduced as far as possible by lining the walls with cork stone, and keeping the doors and windows as tightly closed as possible.

The air entering the rooms at 61 deg. F., and which is heated in the latter to 77 deg. F., would possess a moisture of 59 per cent, thus being enabled to absorb further amounts of vapor.

The advantage of an ice generating and refrigerating room for the preservation of victuals is obvious. The ice generator comprises sheet metal cells filled with refrigerating water and suspended in a salt solution which is cooled down by the machine to 22 deg. to 25 deg. F. The preservation of food is based on the introduction of cold and relatively dry air, which method has been tested in connection with numerous plants of this kind.

The refrigerating machine yielding 24,000 heat units per hour in the case of continuous operation will be able to yield about one-third of its output for the generation of ice and for cooling the store room; the average consumption of cold will in fact be reduced far below the calculated limit. Owing to the more advantageous conditions of the air and to the fact that certain rooms will require to be ventilated only at certain hours, an output of 75 to 80 pounds of ice per hour may be obtained.

The cost of installation for the machinery has been calculated at about $9,000.

The cost of operation in the case of 200 working days per year will be:

For labor	$1,000
For oil for fuel, wear and tear, etc.	875
Total	$1,875

These working expenses will be nearly covered by the generated ice.

The installation of such refrigerating plants can be made far more economical by erecting central refrigerating stations. If several buildings situated at distances of a few hundred yards apart are to be ventilated with cold and dried air such central plants will in fact allow the working expenses to be reduced considerably.

The Prince of Wales on June 12 opened another tunnel under the Thames, connecting Rotherhithe with Stepney and the eastern districts of London. The tunnel cost $10,000,000. The total length is 2,294 yards, of which nearly a third is the open approach. In the center the tunnel boring is only 7 feet below the bed of the Thames, which is at this point 500 yards wide.

KORN'S NEW TELEPHOTOGRAPHIC SYSTEM.—II.

THE COMPENSATING SYSTEM AND OTHER DETAILS OF THE APPARATUS.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

Concluded from Supplement No. 1696, page 15.

WE have already given an account of the new apparatus which has been constructed at Paris for the transmission of photographs to a distance on Dr. Korn's principle. The action of selenium plays the principal part in this apparatus, and much of its success is due to the researches which Dr. Korn has carried out upon selenium cells. He brings out several new points which are of great value for the question of image transmission, especially as concerns the use of a second or compensating selenium cell and also the inertia of the cells in general. The following *résumé* of Dr. Korn's researches has been given by Dr. Glatzel, who is in charge of the photo-telegraphic station now located at Berlin. These data have not as yet been published outside of Germany, so far as we are aware, and they will be of a considerable scientific interest as well as of a practical bearing for future work in this direction.

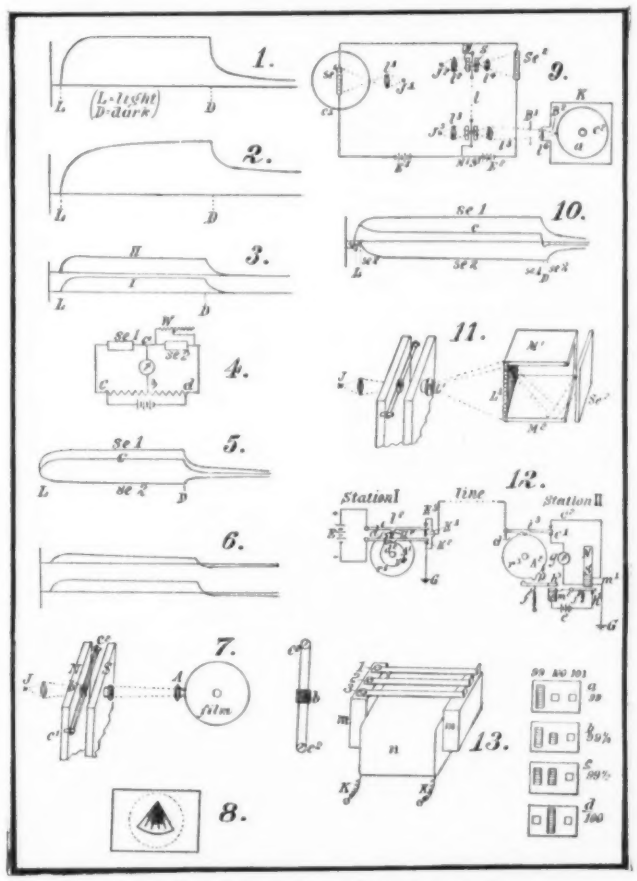
Modern selenium cells are generally made of a porcelain or like support having a double wire wrapped around it, so that the spaces between the wires can be covered with selenium. Such cells have a resistance in the dark which equals 20,000 to 500,000 ohms. When we cause the light to fall upon such a cell, we find that the resistance is not at once lowered accordingly, and a certain time elapses before the proper resistance is reached. On removing the light from the cell in like manner, it does not come back at once to the original value of the resistance in the dark. This property of the selenium cell is known as its inertia. It may be explained in the following way. When the light falls on the cell, the upper layers of the selenium are altered in the first place, as they are directly acted upon by the light, and their resistance is changed. In the underlying layers, the effect penetrates gradually, and thus their resistance is only altered after a certain length of time. It is not as yet clear as to just how this action takes place. Selenium cells with a thin layer of selenium are found to have a smaller inertia than those with thick layers. Since the thin-layer cells have a high electric resistance, and inversely, we may say that under equal circumstances, the cells of a lower inertia have a higher resistance and the cells of high inertia have a lower resistance. If we trace the change of the cell in relation to the time we have an inertia curve for the cell. M. Glatzel obtained an interesting series of such curves by the use of a Siemens & Halske oscillograph and these were photographed. Fig. 1 shows an inertia curve for a cell of small inertia and a resistance in the dark of about 500,000 ohms. Fig. 2 is a curve for a cell having a large inertia and a lower resistance of 70,000 ohms. It is seen from both curves that the change of current (due to the resistance) when lighted is notably quicker than on the darkening. (*L* is the moment of lighting and *D* that of darkening.) In defective cells it may happen that it takes several minutes, even hours, to reach the original point.

For practical uses in photo-telegraphy it was desired to reduce the inertia of the selenium cell as much as possible, and if not entirely, at least to a sufficient amount to give the needed results in this field. Dr. Korn succeeded in finding a means of doing this in his compensating selenium method. By the use of this arrangement we find that the current changes in a cell which has the current passed in it will follow the variations of light very quickly, and we can approach the theoretical and desired perfect action, in which when lighted the cell at once assumes its highest value of resistance; when darkened, the resistance at once drops to the former amount. We approach these conditions in the curve, Fig. 3, which shows the action of a compensated cell. Curve I shows the effect with a light intensity figured at 3, and curve II the action with an intensity of 5. It is not possible, seeing that the inertia curve is different for different lighting of the cell, to compensate a cell exactly for all values of light, but only for one value. In practice, however, we arrive at a practical result, as will be seen.

Dr. Korn's method of compensating is carried out in the folowing manner: When we connect two selenium cells in opposition, it is possible to remove the inertia, or nearly so. We must take care that the differential current from the cells in the lighted state is not a zero value, while in the darkened state it must on the contrary be equal to zero, which case cannot hold good with a single cell, seeing that a current will always pass in it, even though a weak one. In order to reach this condition Dr. Korn places two

PORTRAIT OF DR. KORN TRANSMITTED BY HIS SYSTEM.

cells Se_1 and Se_2 (Fig. 4) in the manner of a Wheatstone bridge. The bridge is so arranged that in the darkened state of both cells there is no current flowing in the galvanometer circuit $a\ b$, seeing that the whole combination is adjusted by the resistances $c\ b$ and $b\ d$ so that this current is brought to zero, in the usual manner. If we choose the two selenium cells so that they have a different sensitiveness to light, we find that on lighting them their resistance is not changed according to the relation which they had when in the dark. They had been balanced, but now the balance is destroyed, changing the equilibrium of the Wheatstone bridge. A current will then flow in the circuit $a\ b$ which will be greater according as the light is greater. This current is the difference of the currents which flow in the cells Se_1 and Se_2. The value of this current and consequently that of the current in $a\ b$ depends on the difference of potential at $b\ c$ and $b\ d$. We can now arrange the bridge so as to secure the best compensation, by means of the sliding contact at b, which varies the resistances. When this is found, we secure the balance of the bridge for the darkened cells by means of an adjustable resistance W, which is connected in parallel with the cell Se_2. This will generally change the first adjustment somewhat, and the final balance is to be secured after several trials. We now have a very good result, which is shown in Fig. 5. Taking the curves by the oscillograph, we find that cells Se_1 and Se_2 taken separately will give the curves which are shown here, while with the compensating arrangement of the two cells as just shown we have the middle curve e which represents the differential current in the circuit $a\ b$. We thus find that the desired result is reached. The current curve has a much better form, especially in the last part, where it is seen that the current drops quickly to the initial value, thus giving but little inertia. But still another arrangement can be used. We can adjust the conditions of the bridge so that the current in $a\ b$ will not rise, but will fall with the time, and the cells can be said to be over-compensated. This is shown in the curves (Fig. 6). With different values for the lighting it was already noticed that there is only one value for which the compensation is obtained. For higher or lower values of light we have an over- or an under-compensation. This holds good for the middle part of the curve and throughout the duration of the lighted period, but here we do not take account of the first rise and the last fall of the curve. But where we have to do with very short light-periods, in which it is only the rise and fall of the curve which is used, we must take care to do away with a slow fall of the current. In this case it is necessary to work with an over-compensation, but not too great. At the same time we



DETAILS OF THE COMPENSATING SYSTEM.

KORN'S NEW TELEPHOTOGRAPHIC SYSTEM.

must have the differential current in *a b* as large as possible in order to secure the best effect of compensation. This is carried out in the first place by a suitable choice of differences of potential for Se_1 and Se_2, and again it can be reached by having the cell Se_2 lighted at a lower value than the first, but at the same time. For each case, the adjustment must be made to secure the best conditions. In practice, the two cells have not the same inertia. Generally the cell Se_1 has a low inertia and high resistance (thin cell) and Se_2 a large inertia and consequent lower resistance (thick cell).

We now come to the practical method which is used in mounting the apparatus for the transmission of photographs to a distant point. At the sending station the different tones of the photographic film are to be translated into the corresponding current values. These currents are sent over the line, and the receiving station must re-translate them into light values so as to act upon the sensitive film and produce the image of the original. In the sending station the selenium cell carries out the first part of the process. For the receiving station, the current values are made to give the proper variations of the light by means of an apparatus designed by Dr. Korn and known as a light-relay or electro-magnetic shutter. Its operation will be seen as follows, referring to Fig. 7. At *N* and *S* are the poles of a strong electro-magnet. Light from a Nernst lamp is made to pass through holes in these pole-pieces. Between the poles is placed a double-stretched wire, c_1 c_2 of copper or platinum, which is very fine. These wires carry the current, and can be stretched more or less by a suitable device, so that the controlling force which brings the system back to the center point can be adjusted according to the desired conditions. At the center of the wires is placed a small square of aluminium foil *b*. The lenses of the apparatus are adjusted so that the shadow of the aluminium piece is made to cover the lens *A* when the whole is at rest, so that normally there will be no light falling upon the sensitive film. This arrangement of magnet and wires resembles the galvanometer which was previously designed by Ader and later on by Einthoven. When a current is sent into the stretched wires, the whole combination will be deflected toward the top or the bottom, according to the direction of the current, and the deflection is larger according as the current is higher. By the proper choice of the controlling force, the highest current in the line can be made to uncover the lens completely and give the highest value for the light. By means of the lens *A* the light is concentrated to a small point which works upon the film. When a weaker current is passed, the light is partly shut off by the foil and the spot on the film is weaker. Thus we form the image upon the film. It is to be observed that the movement of the wires and consequently the value of the light is not always proportional to the strength of the current in the line; that is, a double current does not give a double deflection. It is possible, however, to adjust the galvanometer so that the controlling effect is stronger and the instrument can be worked at a point where the ratio will hold good within the required limits. Another method of securing this effect which is easier to carry out is to make the opening which admits light to the lens, not rectangular, but of another form, so that the amount of light admitted to the lens will vary in a certain way to compensate for the non-proportional variation of the instrument. It is found that a right-angled triangle is the best form for the opening. Furthermore, behind the triangular opening is placed a toned film so that the point of the triangle will be nearly opaque, and the other part lighter, as will be observed in Fig. 8. Such a combined screen is placed in front of the lens, and this method is found in practice to give the desired results. The light values at the receiving film now correspond exactly to those of the transmitting film.

The present form of electro-magnetic shutter is well adapted for the present work, owing to the fact that it possesses a very small inertia, owing to the lightness of the moving part. The normal vibration period of the wires is from 0.01 to 0.02 second. This allows the use of a rapid succession of impulses in the line, which is necessary in order to give the transmission of a photograph within a reasonable time. The compensating cell method also allows of increasing the speed of operating over what would be required with ordinary cells, so that in the present apparatus a very good speed can be obtained. In the first experiments with the ordinary cell, a view measuring 4 by 5 inches took 30 minutes to transmit, while at present Dr. Korn's apparatus will transmit a 5 by 10-inch image in 6 minutes.

However, there is another use of the electro-magnetic shutter which plays a very important part in the present apparatus, and it is used to throw the light upon the compensating cell, so that the lighting of this cell can be carried out independently of the lighting of the main cell. This is shown in Fig. 9. The compensating cell Se_2 is lighted by the Nernst lamp J_2 and in the path of the beam is placed the electro-magnetic shutter *N S*, which is connected in the Wheatstone bridge arrangement in series with the line *l* and the electro-magnetic shutter N_1S_1 of the receiving station. When cell Se_1 is lighted, the bridge balance is destroyed and a current flows in the bridge and consequently in the shutter *N S*, so that a certain amount of light is sent upon Se_2. Owing to the slight inertia of the shutter, the cell Se_2 is lighted somewhat later than Se_1, and the two curves of Fig. 10 are thus slightly displaced, as will be seen. The curve of *C* of the bridge current, which is the difference between the current in Se_1 and Se_2 will thus take another form. The first rise of the curve *C*, which is of importance here, will be somewhat steeper, and this gives a better result in the case of rapid series of light variations. Thus we can have an action even from a very short change in the light, which would otherwise be lost. Again, at the other end of the curve, the change upon darkening the cells is also much better, and is nearly instantaneous, so that under such conditions the compensation as a whole is brought to a very good point. Thus it will be seen that the use of the light relay in the compensation brings about excellent results.

In the newer apparatus, the compensation is thus carried out and we are now able to place Se_2 in the sending station, while before it was placed at the receiving end.

At each station the apparatus includes a transmitter and a receiver, placed side by side. The receiver contains a light relay for sending the beam upon the film, as we have seen, but as this is out of use when the transmitter is working, it is used to operate the compensation for the transmitter. In this case the beam is cut off from the film and passes instead into the compensating cell. Thus the light relay *NS* (Fig. 9) works at the same time as the corresponding relay N_1S_1 of the receiving station. This has another advantage in enabling the sending operator to check up the work as the movement of the shutter takes place at the same time. In Fig. 11 is shown the method of lighting the compensating cell by means of the light-relay. The cell Se_2 is placed on the back face of a cubical chamber which has the two mirrors M_1 and M_2 at the top and bottom, respectively. The front is closed by a set of glass rods L_2. On this part is thrown the shadow of the light-relay and when no current is passing, the inside of the box is in the dark. When current passes, the shadow moves, and allows more or less light to enter and reach the selenium. The glass rods act as cylindrical lenses so as to give the proper diffusion of the light all over the selenium (when combined with the mirrors), even when only a part of the surface L_2 is lighted. This point is of importance, as it would not be practicable to have the cell lighted more in one point than in another, which would happen if the shutter alone were to be used, because the action of the selenium would be quite different in such case. In practice the beam of light is sent from the light-relay either to the receiving film (when the receiver is used at the first station) or else by a proper reflecting arrangement, upon the compensating cell, as we have just seen, when the transmitter is working.

It is necessary to have both the cylinders at the sending and receiving ends driven at exactly the same speed, and these are driven by two synchronous motors. In the present case these are direct current motors, but upon the armature of the motor is mounted a set of collector rings at the other end in order to produce an alternating current. This is done so that such current can be sent into a synchronous indicator which will be described, and it is thus very easy to regulate the proper speed of the two motors. The general method of connecting the motors upon the line is shown in Fig. 12. The motor of the receiver is regulated so that it runs about 1 per cent faster than the motor at the other end, each motor being driven independently by a battery. The receiver motor comes to the end of its revolution before the second motor. It is automatically stopped here by a magnet-operated pawl. When the second motor finishes its revolution, it sends a current into the line which acts upon the magnet and releases the pawl, so that both motors take a fresh start and exactly together. Thus the speed is corrected at the end of each revolution, and this point is made to lie at the bottom of the photograph, so that there is no effect on it.

The connections are as follows: The electro-magnet m_2 of station II is operated by means of the polarized relay NSm_1h_2, which is connected upon the main line and with station I (the line is also used for the photographing) in the following way: The armature of magnet m_2 is provided with a projection which works on a pawl on the disk A_2 placed on the shaft of the motor. The disk forms part of a friction clutch which lies between the motor and the cylinder. When the pawl *p* comes next the projection, it is held fast, and the cylinder ceases to turn, while the motor continues to rotate. This holds good until a current impulse is sent from station I by means of the system of projections and leaves d_1d_2 placed on the motor shaft. Then the armature h_2 of the magnet m_1 is attracted and opens the circuit of magnet m_2 so that the cam *p* is released. The cylinder then continues to rotate. When the synchronizing impulse comes, this current must not be sent into the galvanometer, as it would injure it. The latter must therefore be cut out of the circuit for an instant. To this end the cam d_2 operates the lever l_2 seen above, and the lever works the contact c_1 and c_2, so that c_2 is thrown off the line and c_1 thrown on, thus cutting out the galvanometer *g* and sending current into the polarized relay *NS*.

In order to regulate the speed of the motors at each station, an interesting form of synchronism indicator is used (Fig. 13). It consists of a laminated piece *m* which contains a winding *n*. The alternating current from the collector rings of the motor is made to pass in the coil. Fixed to the electro-magnet are a number of steel tongues 1, 2, 3, which have one end free and can thus vibrate. The tongues are regulated so that they are in unison for different rates of vibration, and thus when the alternating current gives 99, 100 or 101 periods per second, the corresponding tongue will vibrate. In this way we have the indications seen at *a*, *b*, *c*, *d*. Where the tongues are not exactly in unison, as at *b* and *c*, the vibration is shorter. In practice each station has a similar instrument, and the motor of the receiving station is adjusted at the point *d* and the second motor at the point *a*. This simple arrangement makes it quite easy to regulate the motor at each end before commencing the photograph transmission. A telephone in each station is used to give the needed signals regarding the adjustments of this and the other parts of the apparatus.

HELICOPTER AND AEROPLANE.

By OTTO G. LUYTIES.

THE helicopter type of flying machine has been comparatively neglected. Although suggested several centuries ago, supposedly by Leonardo da Vinci in 1500, much less work has been done on it than on other types of flying machines. Not a single man-carrying helicopter has ever been flown in free flight.

This neglect of the helicopter-type appears to have been due to a general impression that it does not offer a likelihood of success equal to that of the aeroplane or even of the ornithopter. It has, in fact, frequently been contended that even if one of large size could actually be constructed, and should be found convenient in operation, it would still be found very low in efficiency.

It will be the effort of the writer to briefly recount the occasionally admitted advantages of operation, and then to demonstrate that the mechanical efficiency of a properly constructed rotary machine is actually higher than that of the aeroplane. For convenience we may itemize the points to be discussed as follows:

OPERATION.	EFFICIENCY.
1. Starting	7. Simplicity
2. Ascending	8. Safety
3. Balancing	9. Head Resistance
4. Hovering	10. Lift per square foot
5. Descending	11. Lift per horse-power
6. Landing	12. Horizontal speed

1. The starting of a helicopter is comparatively simple, especially if it be of the vertically ascending type. It is merely a matter of starting up the propellers without requiring a special launching device or a long run on a smooth ground, as required by the aeroplane. This is important because such launching devices will not always be available and because large, smooth, open spaces are uncommon.

2. A helicopter can ascend nearly vertically. It can therefore arise from small starting places such as a small field surrounded by large trees. In actual use flying machines will encounter many obstacles such as high houses or steep hillsides. Such obstacles a helicopter will be able to surmount by simply rising at a steep angle, whereas an aeroplane will be compelled to turn completely around and ascend in a large spiral. It is evident that the ability to fly at any angle with the horizontal will be of great advantage to the helicopter.

3. The balance of a helicopter may be made practically automatic. It is evident that the simplest way to secure equilibrium is by using a very low center of gravity. The known objection to this construction is that it causes excessive pitching and rolling. Now in an aeroplane, violent pitching absolutely destroys its power to fly, as it spoils the all-important angle of incidence of the supporting planes. But in a helicopter the essential angle of incidence is the angle of the blades with the shaft, which remains practically constant whether the machine as a whole pitches or not. Therefore a helicopter can be arranged to have a more pronounced pendular stability than is possible with an aeroplane. The helicopter, furthermore, may readily be designed to have gyroscopic stability, without requiring as much special apparatus for this purpose as would be required by an aeroplane.

4. A practical helicopter will be able to hover over a selected point, whereas an aeroplane must continually

move horizontally in order to retain its elevation. The ability to hover should prove a great advantage, for instance in taking observations and in selecting a suitable landing place.

5. A helicopter under good control could descend at any desired speed and at any angle, or vertically if preferred. It could, in an emergency, descend in a contracted space much too small for the flight of an aeroplane.

6. Landing will always be difficult. It is particularly dangerous in an aeroplane owing to the high horizontal velocity. At present aeroplanes can only land safely on smooth ground in large open spaces. It may be found possible in later models to suddenly check the horizontal velocity at the exact moment of landing, but the general nature of the difficulty will still remain the same.

A practical helicopter would be able to descend slowly in any open space of moderate size and land safely whether the ground be smooth or not. If under perfect control it could land without any horizontal velocity either in a calm or in any moderate wind.

The above described favorable characteristics of a practical helicopter have been pointed out by other writers and are here repeated only for convenience. With one or two possible exceptions they have been described by Penaud, Chanute, and Hastings.

The mechanical efficiency of the helicopter, however, has apparently not been so carefully studied nor so correctly judged, so that it merits further examination and discussion.

7. The helicopter can be constructed more simply than the aeroplane. In the former, the power is applied directly to the inclined surfaces, whereas in the latter the power is transmitted to a propelling device, and the resultant thrust applied to the planes. It will be clear, without elaborate explanation, that simplicity is especially desirable in flying machines, as weight and power are both limited, and as simplicity in these fragile structures favors reliability and safety. As this article is intended to deal only with general principles, details of structure will not be here discussed.

8. The achievement of reasonable safety is essential to practical flight. Special provision must be made against the occurrence of an unretarded fall and consequent complete destruction. Of course all heavier-than-air flying devices must fall in case of serious accident to their means of sustentation. In this contingency, however, they should not drop too rapidly nor upset in falling.

Now the supporting power and stability of an aeroplane are largely dependent upon the continuance of its motive force. Stoppage of the motor means a sudden drop and a sudden backward shift of the center of pressure. This is liable to cause a complete somersault, particularly as the center of gravity in an aeroplane is necessarily high and as curved surfaces such as are usually employed are in themselves unstable with the concave side downward. An expert operator may occasionally, if the motor stops, be able to glide to the ground in an aeroplane as if with a gliding machine, but the actual landing is then likely to occur at a dangerous horizontal velocity.

Of course a helicopter will also drop if its motor stops, but its stability need not be seriously affected. The drop may be made vertically, if preferred, or be given a slight horizontal component. The speed of falling will depend largely upon the weight per square foot, so that the advantage of large areas in this contingency is apparent. The low center of gravity will tend to keep the machine right side up. In addition to this, the supporting surfaces may be arranged to have a slow reverse rotation about their shafts, thus forming an efficient and stable rotatory parachute. The rate of fall probably need not exceed 20 to 30 miles per hour with weights of one or two pounds per square foot, or about the landing speed of a man jumping from a height of 15 to 25 feet. An emergency descent at this rate would not generally seriously endanger the life of the operator.

9. The helicopter has a considerable advantage over the aeroplane in the matter of head resistance. Considering only the forward progress of the machine as a whole it will be clear without explanation that a helicopter flying with about three-quarters of the horizontal velocity of an aeroplane will have approximately half its head resistance if the bulks are about equal. In order to analyze the matter, however, we may divide the total head resistance into two parts, namely, the back pressure of the supporting surfaces, sometimes called the drift, and the head resistance of the car and body of the machine. The back pressure of the supporting planes may be divided into three parts, the head resistance of the front edges, the skin friction, and the horizontal component of the normal pressure.

Now as far as the head resistance of the car and body is concerned, the helicopter has the advantage of a slower horizontal speed. At the time of starting this advantage is most pronounced as the aeroplane has to overcome its full head resistance when first leaving the ground, whereas the car and body of the helicopter offer no horizontal head resistance at all during the difficult period of starting.

The head resistance of the supporting surfaces has heretofore generally been higher on models of helicopters than on aeroplanes. This is, however, entirely unnecessary as it is only a question of using proper areas, speeds, and angles to get the same ratio of lift to drift in a helicopter blade as in an aeroplane surface, provided that proper allowance be made for the helicopter blades working in disturbed air.

We may reasonably conclude that the head resistance of the supporting surfaces of a properly-designed helicopter will be about the same as that of an aeroplane, and that the head resistance of the car and body will generally be less, principally owing to the slower horizontal velocity.

10. In the matter of lift per square foot the helicopter has this advantage over the aeroplane, that it may be designed with any desired lift per square foot within wide limits without materially affecting the horizontal velocity of the whole machine or the head resistance of the car and body.

It has been urged in favor of the helicopter that this fact will permit of the use of very small areas, thereby reducing the weight of the supporting surfaces. The writer does not recommend this construction, particularly not for use during the present early stage of the art, as it is dangerous in case of a sudden fall, and as it requires very light construction and inordinately powerful motors. It should also be observed that the use of high speed and very small areas reduces the lift per horse-power and consequently the efficiency of the helicopter as a lifting device.

Nevertheless, the fact that the lift is practically independent of the horizontal velocity of the machine as a whole is a great advantage of the helicopter over the aeroplane and itself accounts for the majority of the advantages in operation referred to earlier in this article.

11. In the matter of lift per horse-power the helicopter has heretofore been stated to compare unfavorably with the aeroplane. A number of authorities, including Chanute,* give the lift per horse-power of a helicopter as about half that of an aeroplane. As this question is of considerable importance, and as the author believes his deductions to be original, the matter will be discussed in some detail.

It will probably be granted that the blades of a helicopter may be considered as aeroplane surfaces of the same area and inclination moving with the same linear velocity, provided that proper allowance be made for the effects of rotation, particularly centrifugal force and operation in disturbed air. The writer contends that the helicopter provides a simple and efficient method of direct drive for the supporting surfaces. The lifting force of a helicopter will be full thrust of the shaft, or, in other words, the full lift of the supporting surfaces directly driven by the motor.

Now in an aeroplane, the supporting surfaces are indirectly driven by the motor through the horizontal thrust exerted by the propeller. This has been described as a means of actually increasing the efficiency, since the total lift of an aeroplane is equal to the thrust of the propeller multiplied by the ratio of lift to drift of the supporting surfaces. Thus it has been found, for instance, that a propeller giving a thrust of eight pounds per horse-power when driving an aeroplane with a ratio of lift to drift of 5 to 1 would support a total weight of 40 pounds per horse-power. This has been described as a method of increasing the lift per horse-power because the same propeller used directly as a helicopter would evidently support only eight pounds per horse-power.

The error lies in the assumption that this same propeller would actually be used in this way, whereas propellers intended for use as helicopters can actually be constructed to give a thrust of over 50 pounds per horse-power. The reader may wonder why, if this be correct, propellers giving such a large thrust are not used on aeroplanes, thus obtaining a still larger lift and preserving the supposed advantage of aeroplanes.

It should be remembered that the screw propeller is simply a mechanical device for exerting thrust or pressure. As soon as this pressure is exerted over a given distance the work done can be expressed in foot-pounds or horse-power. For any given efficiency, therefore, the thrust that can be obtained per horse-power will vary inversely as the distance through which it is exerted. A propeller of perfect efficiency for instance could give a thrust of 8 pounds per horse-power at a velocity of 69 feet a second or about 47 miles an hour. Another propeller also of perfect efficiency might give a thrust of 50 pounds through a distance of 11 feet per second or about 7½ miles per hour. These are the theoretical maxima for the given speeds, the distances per second through which these thrusts could actually be exerted being much less, owing to the yielding of the air, skin friction, etc. Now it is well known that the yielding of the air is relatively larger for propellers progressing slowly along their axes, but even so, the largest thrusts can be exerted at the slowest speeds if the propellers are properly designed for their work.

If the slip in the cases suggested above be assumed as 8 miles per hour in one instance, and 5 miles in the other, being about 17 per cent in one case and 67 per cent in the other, the first propeller will give a thrust per horse-power of 8 pounds at 38 miles an hour, the second a thrust per horse-power of 50 pounds at 2½ miles. These figures are fair examples that might occur in actual construction.

As aeroplanes require a considerable horizontal velocity in order to fly at all, it is evident that they will always be limited to the use of propellers giving only moderate thrusts per horse-power. It is the contention of the author that this more than balances the advantage of the favorable ratio of lift to drift of the supporting surfaces. The aeroplane, considered as a supporting device, also has in its propelling mechanism a source of inefficiency not occurring in the helicopter.

The helicopter is handicapped by having its blades work in disturbed air. This disadvantage is a serious one, but is not quite as great as generally supposed, because the drift is reduced at the same time as the lift and nearly in the same proportion. As soon as the helicopter moves horizontally its blades act on fresh air and the lift is slightly increased.

The helicopter is sometimes stated to lose in efficiency owing to the action of centrifugal force. It is assumed that air is thrown outward, requiring power without giving an adequate supporting reaction. Now as a matter of fact the centrifugal action must be very small if it occurs at all, because it is shown by experiment that there is an actual inrush of air around the circumference of a helicopter and even for a short distance below its blades. In any case, as centrifugal force depends largely upon the angular velocity, it may be reduced by using large diameters and low speeds and by adopting an efficient form of blade.

Considering both types of machines in a general way the incidental head resistance will also reduce the lifting efficiency, but as the helicopter at its usual slower speeds will have a smaller head resistance of car and body than the aeroplane, it will lose less power from this source. The writer is inclined to believe that the advantage of reduced head resistance will balance the disadvantage of working in disturbed air, but this can be definitely determined only by actual experiment on a large scale.

As far as theory is concerned the author holds that the direct drive of the helicopter is more effective than the indirect drive of the aeroplane, and that with suitable construction the helicopter will actually give a larger lift per horse-power.

12. The writer contends that the helicopter will have a higher horizontal speed and greater translational efficiency than heretofore supposed. It is apparently generally believed that the velocity of the forward motion will depend simply upon the cosine of the angle of inclination of the main shaft with the horizontal. This would make the maximum attainable horizontal speed equal to the maximum theoretical pitch velocity times the cosine of the angle. The actual horizontal speed would naturally be estimated at less than this owing to the head resistance of the car and body.

But the author contends that the horizontal speed will exceed this supposed theoretical maximum and may even exceed the full theoretical pitch velocity. This is a striking paradox, but if correct is important and therefore worthy of careful analysis.

Let us consider the thrust along the inclined shaft to be divided into two components, the one vertical, the other horizontal. Let us assume the vertical component to be balanced by the weight. Let us further assume the effective pitch angle of the blades to be for example 12 degrees and the angle of the main shaft with the horizontal 78 degrees. The currently accepted computation would then give a maximum horizontal speed of about one-fifth of the pitch velocity.

Let us now analyze the action of the blades. In the assumed case they will make no angle with the horizontal on the forward stroke and double the pitch angle with the horizontal on the back stroke. Then the forward stroke will have a lifting effect, but practically no horizontal component. This is because the pressure on an inclined plane is always perpendicular to the surface.* Of course there may be a slight backward horizontal pressure due to skin friction, or a slight forward horizontal component, if the surface be slightly curved, due to the tangential force described by Lilienthal,† but for practical purposes the pressure on the forward stroke may be considered vertical.

The back stroke will give a strong forward thrust on acount of the pronounced angle of the blades with the horizontal. This will continue as long as the blades move backward faster than the whole machine moves forward. This forward thrust, at least during the cen-

* "Progress in Flying Machines."

* See Aeronautics, vol. I., No. 3, page 11, September, 1907.

† See Moedebeck's Handbook, English Edition, page 280.

tral part of the back stroke, will not disappear entirely until the horizontal velocity of the whole machine equals the linear rotational velocity of the blades. But the linear velocity exceeds the pitch velocity if the pitch be less than unity.

Therefore the attainable horizontal velocity exceeds the pitch velocity times the cosine of the angle and may even exceed the full theoretical pitch velocity. It is thus a fact that a slightly inclined helicopter may travel horizontally faster than it would if used directly as a horizontal propeller.

It immediately follows from the above that the horse-power required for horizontal motion will not be as high as might otherwise be the case, the power for vertical support being separately considered. The efficiency of a helicopter as a vehicle for horizontal transit will also be fairly good if driven by a special horizontal propeller intended to increase the horizontal velocity, provided that the main shaft be inclined forward at a suitable angle in order to take advantage of the above described peculiar feathering action of the main blades.

It thus appears that the maximum horizontal velocity and transit efficiency of the helicopter, although lower than those of the aeroplane, will be sufficiently high for practical use and very much higher than heretofore supposed. It will always be an advantage that the horizontal velocity can be regulated, and especially that it can be reduced to practically nothing whenever desired.

SUMMARY.

In summarizing our conclusions we may say that the helicopter can be made superior to the aeroplane in the first nine points considered, namely: starting, ascending, balancing, hovering, descending, landing, simplicity, safety, and head-resistance. The author also contends that the helicopter may be designed to have a very large lift per square foot, or a very large lift per horse-power, and that its horizontal velocity, although less than that of the aeroplane, will be considerable, variable, and sufficient.

As this article is limited to a theoretical discussion, the desirability of testing the conclusion in practice is evident. The author is engaged in experiments along this line and expects soon to publish the results of some tests of a large helicopter. The important questions of lift per horse-power and of horizontal velocity appear to be especially worthy of discussion and experiment. The author hopes that this article may serve to arouse greater interest in the comparatively neglected helicopter-type of flying machine and that the merits here asserted and discussed may be fully confirmed in actual practice.

Baltimore, Md., March, 1908.

CALCULATING PORTLAND CEMENT CLINKER.

THE usual rule for calculating the clinker formed by burning a raw material is to add the percentages of silica, oxide of iron and alumina, lime, and magnesia and to divide this sum into the percentage of each compound, multiplied by 100, for the percentage of that compound which will be present in the clinker. The results thus obtained for silica, for iron oxide and alumina will be too low and the lime much too high. This is because the ash of the fuel enters into the composition of the clinker, and also because the clinker contains constituents present in the raw materials not entirely volatilized in burning, viz., soda, potash, sulphur trioxide, etc., carbon dioxide and water.

To calculate the composition of the clinker from the analysis of the raw material is therefore impossible, and we must assume certain corrections. First of these is for the coal ash entering into the clinker. Experiments show that in the rotary kiln about one-half of the ash enters the clinker. West Virginia gas slack coal averages about 10 per cent ash, composed of about 40 per cent silica and about 20 per cent each of iron oxide and alumina. If 90 pounds of coal are required to burn a barrel of cement, about 15 pounds (equivalent to 1.5 pounds of ash) are required per 100 pounds raw material burned. If half the ash enters the raw material, the silica is increased by $\frac{1}{2} \times 1.5 \times 0.40 = 0.30$ per cent, and the iron and alumina each $\frac{1}{2} \times 1.5 \times 0.20 = 0.15$ per cent.

Analyses of Lehigh Valley clinker, fresh from the kilns, show it to contain about 2 per cent of potash, soda, sulphur compounds, carbon dioxide, and water combined. Clinker from other localities will probably not vary widely from this.

Assuming the above corrections the rule for calculating clinker from the mix analysis is as follows:

Add the percentages of silica, oxide of iron, alumina, lime and magnesia. To the sum add 2.75. Call the result the "clinker total."

To find percentage of silica, add 0.30 to the percentage of silica in the raw material, multiply the sum by 100 and divide the "clinker total" as found above. The result will be the percentage of silica in the clinker.

To find percentage of iron oxide or alumina add 0.15 to the percentage of iron oxide or alumina in the material, multiply by 100 and divide by clinker total.

To find percentage of lime or magnesia, divide percentages of these by clinker total.—From The Chemical Engineer.

TRADE NOTES AND FORMULÆ.

Yeast Wine.—Pour 100 parts of water in which 12 to 14 parts of white loaf-sugar have been dissolved onto 40 parts of fresh wine yeast and allow the whole to ferment at 41 deg. F. The fermented wine is drawn off from the yeast and may be further fortified by the addition of spirits.

Berlin Yeast Flour (baking powder) consists of 4 parts of purified cream of tartar, 2 parts of carbonate of soda and 1 part of flour. Also a mixture of 15 parts of tartaric acid, 16 parts bi-carbonate of soda, 16 parts powdered starch and 2 parts of carbonate of ammonia. This will yield an excellent preparation, closely resembling Berlin yeast flour. The carbonate of ammonia may be omitted, but with it a much whiter bread can be made than where it is left out.

Process of Hardening and Coloring Natural Plaster (**Heinemann**).—The articles made from crude plaster are heated to 212 deg. to 228 deg. F., put first in concentrated solution of calcium chloride, then in a hot, concentrated solution of sulphate of magnesia, and finally then laid in water. These operations are repeated several times (the temperature being, if desired, increased to 212 deg. F.) After impregnation, the pieces should be treated alternately with glue and tannin solutions, each time from 1 to 4 days, finally dried in a drying room at a decreasing temperature. For colored marble, add to the chloride of calcium solution such metallic chlorides as will produce, with the subsequent treatment with metallic salts, colored, insoluble deposits.

Preserved Yeast.—Reinke proceeds as follows for the preparation of yeast that will remain for months and years good for use in fermentation industries. About 2 ounces at a time of the well-washed and thoroughly pressed pure-culture yeast is quickly enfolded in a dustless damp place in two sheets of blotting paper, sterilized by being kept, for three hours, at a temperature of 275 deg. F. The yeast is then rolled flat, again wrapped in blotting paper (if necessary sprinkled with boracic acid) and deprived of water by pressing between sterilized asbestos slabs. After changing the asbestos sheets several times, the packages of yeast and the blotting paper, several together, are packed in tin boxes, the interspaces being filled with burned gypsum (which absorbs the last traces of moisture) and the tin boxes soldered up. The removal of water from the yeast must be effected as rapidly and at as low a temperature as possible. (The process unless most carefully conducted will probably hardly ever yield satisfactory results.) The details are here given merely as a suggestion for experiment.

Bouillon Tablets.—Remove the fat from good beef, boil the latter in a covered pot with sufficient water to cover the meat for about 8 to 12 hours, clearing away all the scum and occasionally stirring. Pour the broth thus obtained through a hair sieve, remove the grease from the surface of the broth, and allow the latter to get cool. A jelly is thus produced, which should be boiled for two hours in a tinned saucepan placed in a caldron with water, under which a fire is lighted. The saucepan containing the bouillon must not be put on the fire, or the bouillon would burn. Be careful not to allow any water from the caldron to get into the saucepan, press the film forming on the surface of the bouillon carefully under the broth, pour the jelly when well thickened into a shallow porcelain dish, when cold cut into pieces of any desired shape, and allow to dry at a moderate temperature. Use about one-third to half an ounce of solid bouillon to a soup-plateful of boiling water, add soup greens and spices, and when the tablet is dissolved boil up the fluid once more.—Der Industriöse Geschäftsmann.

Solder for Cast Steel.—*a*. Borax 64 parts, sal ammoniac 20 parts, ferrocyanide of potassium 10 parts, rosin 5 parts. A small quantity of water and some brandy are mixed together, and while constantly stirring heated and dried in an iron vessel. *b*. Boracic acid 41.5 parts, common salt 35 parts, ferrocyanide of potassium 15.5 to 26.7 parts, rosin 7.6 parts, calcined soda 3 to 5 parts. The steel objects to be soldered should be heated to a red heat. Increase this heat and complete the soldering, using the powder according to the ordinary process. *c*. 61 parts of borax, 17 parts of sal ammoniac, 52 parts of ferrocyanide of potassium and 5 parts of rosin. The borax and sal ammoniac are to be powdered and fused in an iron vessel. The heating is continued, stirring vigorously the while, as long as a strong odor of ammonia is noticeable, the evaporated water is replaced from time to time by the addition of a small quantity of fresh water. When the ammonia odor has completely disappeared, add, in the iron vessel, the pulverized ferrocyanide of potassium and rosin, and heat the whole, stirring constantly, until a uniform paste is produced. The molten mass is spread by means of an iron spatula on a sheet of iron, where it is dried at a moderate heat and finally pulverized. The resultant soldering powder must be kept in closely sealed vessels. In soldering, it is to be spread on the hot steel, proceeding as above described.

SCIENCE NOTES.

The experiments of Prof. Miethe of the Charlottenburg Technical College have resulted in what is claimed to be a very cheap and practicable way of producing artificial rubies, sapphires, and emeralds, and also alexandrite, a rare and expensive gem hitherto found only in small quantities in Russia. He has not yet succeeded in manufacturing a good imitation of the diamond, but this he announces he expects to accomplish very soon. He has been most successful with rubies. These he manufactures in various shades, including the much sought after pigeon's blood. It is said that by Prof. Miethe's method rubies and sapphires can be produced profitably at from $2.50 to $3.75 a carat, and alexandrite at $10. The cost is pro rata regardless of the size.

C. Benedicks in Metallurgie shows that graphite is soluble in iron in the following way: A Swedish gray pig-iron, containing 3.9 per cent of carbon, 0.75 of silicon, 0.37 of manganese, and small quantities of sulphur and phosphorus, was first converted into a mixture of ferrite and graphite, by rapidly heating the metal to above 800 deg. C., allowing it to cool slowly during several hours, rapidly re-heating to a point below the original temperature, allowing to cool slowly, and repeating this procedure a number of times. Microscopic examination of the metal finally obtained showed that all pearlite and cementite had disappeared, and that it consisted only of ferrite and graphite. The metal was then heated to 940 + 10 deg. C. for one or two hours, and quenched in rape oil. Microscopic examination now showed the presence of considerable quantities of martensite, troostite, sorbite, and pearlite, so that at 940 deg. C. graphite appears to be appreciably soluble in iron.

Colloidal sulphur, under the name of sulfoid, has been introduced as a substitute for ordinary sulphur and the alkali polysulphides. It may be used in the form of a 2, 5, or 10 per cent solution, or applied with Lassar's paste in a 10 per cent combination. It is also prescribed in the following ointment: Sulfoid, 10; salicylic acid, 2; white soft paraffin, 88. A substitute for Vlemingkx's solution is obtained with the following paste: Sulfoid, 50 grammes; distilled water, 350 grammes; soft soap, 150 grammes; synthetic neroli oil, 5 drops. In preparing solutions of various prescribed strengths the sulfoid should be shaken up with the water and allowed to stand, with occasional agitation. In preparing ointments with sulfoid, it should be rubbed down with a little water and allowed to stand for a short time before mixing with the basis.—Pharm. Zentralh.

German forestry is remarkable in three ways. It has always led in scientific thoroughness, and now it is working out results with an exactness almost equal to that of the laboratory; it has applied this scientific knowledge with the greatest technical success; and it has solved the problem of securing through a long series of years an increasing forest output and increasing profits at the same time. Like other advanced European countries, Germany felt the pinch of wood shortage a hundred and fifty years ago, and though this shortage was relieved by the coming of the railroads, which opened up new forests, and by the use of coal, which substituted a new fuel for wood, the warning was heeded, and systematic State forestry was begun. After all, the scare was not a false one, for even to-day Germany is not independent as regards wood, since she has to import one-sixth of all she uses. In addition to the wood-supply question, Germany was forced to undertake forestry by the need of protecting agriculture and stream flow. The troubles which France was having with her mountain torrents opened the eyes of the Germans to the dangers from floods in their own land. As a result the maintenance of protective forests was provided for by Bavaria in 1852, by Prussia in 1875, and by Württemberg in 1879.

TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—Helicopter and Aeroplane.—By OTTO G. LUETTES..... 32
II. CHEMISTRY.—Calculating Portland Cement Clinker..... 32
III. ELECTRICITY.—Elements of Electrical Engineering.—XXI.—By A. E. WATSON, E.E., Ph.D.—6 illustrations..... 33
Korn's New Telephotographic System.—II.—2 illustrations..... 35
IV. ENGINEERING.—A Cooling Installation for Hot Countries.—By Dr. A. GRADENWITZ.—5 illustrations..... 35
Combination System of Reciprocating Engines and Steam Turbines.—By C. A. PARSONS and R. J. WALKER..... 37
V. MATHEMATICS.—Mathematical Prodigies..... 38
VI. MINING AND METALLURGY.—A $25,000 Stope Drill Competition in South Africa.—6 illustrations..... 38
VII. MISCELLANEOUS.—Science Notes..... 39
Trade Notes and Formulæ..... 39
VIII.—ORNITHOLOGY.—A Statistical Study of Midsummer Birds of Illinois..... 39
IX. PHOTOGRAPHY.—The Making of Moving Pictures.—I.—By GUSTAVE BABIN.—14 illustrations..... 40
X. PHYSICS.—The Theory of Diabolo.—By C. V. BOYS, F. R. S..... 42
The Aerodromometer..... 42
XI. TECHNOLOGY.—Disposal of Coal Tar.—By CARROLL MILLER..... 42
Clarifying Waste Water from Dye Works.—By ROBERT GRIMSHAW..... 42
Artificial Silk..... 43
Method of Fireproofing Wood and Textile Fabrics..... 43